The Canadian Entomologist.

LXXX Guelph, January - December, 1948 Nos. 1-12

Wars, rumours of wars, preparations for wars, are, in general, very unfavorable to science, either as a practical pursuit with humanitarian objectives or as a balanced speculative activity.

It is true that the vital necessity of success in attack or defence, now induces enlightened governments to lean heavily, in wartime, on the scientific corporation, which can count on financial support not usually forthcoming in peace-time. Investigations subsidized for military purposes have undoubtedlyl produced results of theoretical interest and practical value: air transport has been perfected, new germicides and repellents for disease-carrying insects have been developed, new and delicate surgical operations have been worked out. However, the benefits derived from such by-products of war are far outweighed by the effects of discoveries utilised for destruction; by the annihilation of materials and records and the interruption of studies of a beneficial or, at least, a harmless character. Moreover, it is not at all certain that the most important scientific results emerge from disciplined and coordinated teamwork. All things considered, science is usually a war-time casualty.

Scientific journals, expensive to produce and scantily supported nearly always run into difficulties in war-time. Contributors are drawn away from their normal avocations into the military effort, so that there is a shortage of manuscripts. Shortages of labour and materials develop, hampering production still further. These inconveniences cannot and do not disappear with the cessation of hostilities. Some time elapses before conditions return to normal. Furthermore, the effects of the difficulties are cumulative.

The effects of war-time conditions on the Canadian Entomologist can be seen clearly enough in the last five or six volumes. At one time, the journal was mailed early in the month given on the cover. Assuming, that it should be mailed on the first of each month, we find that in 1942 there is an average mailing delay of 43 days; in 1943, of 46 days; in 1944 of 48 days. In 1945 this rises to 141 days and in 1946 to 185 days. For the 1947 volume, the average delay was over 200 days and in fact the later numbers of this year have appeared over a year late. Eventually, the supply of manuscripts began to fall off. At the end of 1946, three double numbers appeared containing respectively 23, 27 and 19 pages, which is less than a normal single number. By the end of 1948, it became evident that a readjustment by the issue of monthly numbers of the journal, was practically impossible.

The Directors of the Entomological Society of Ontario therefore decided to utilise the available manuscripts for the preparation of a complete volume representing the year 1948 (Vol. LXXX). This contains an account of the proceedings of the 50th anniversary meeting of the Montreal Branch of the Entomological Society of Ontario and is issued as a Commemorative Volume. It has not been possible to expand it to normal dimensions. Nevertheless the preparation, within a short period, of the Commemorative volume, together with the double number for November and

December 1947 and the first number of the 1949 volume, has entailed an unusual amount of labour and was only made possible by the generous co-operation of Professors A. W. Baker, R. H. Ozburn and members of their Department, who have assisted the Editor in arranging material, reading proof and supervising printing.

It is hoped that from January 1949 the Canadian Entomologist will appear promptly, at fairly regular monthly intervals and with certain improvements in paper and format. To finance the journal under present conditions an increase in membership fees, subscription price and advertising rates, has been necessary. The Directors are confident that the members of the Entomological Society of Ontario, the subscribers to the Canadian Entomologist and the advertisers also, will accept and approve the action taken and will provide the support necessary to enable this very old and respected journal to continue its services to the entomological corporation.

W. R. Thompson,

Editor, Canadian Entomologist.

SEVENTY-FIFTH ANNIVERSARY MEETING OF THE MONTREAL BRANCH OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

1873 – 1948

The Eighty-Fifth Annual Meeting of the Entomological Society of Ontario, which celebrated the Seventy-Fifth Anniversary of the Montreal Branch of the Society, was held in Montreal on November 3rd, 4th and 5th, 1948. The meetings were held at McGill University and Université de Montréal. One hundred and sixty-one members and visitors were registered for the meetings.

The arrangements for the meeting were in the hands of a local committee of Messrs. Monro, Bellemare, Morrison and Stanley, and a programme committee of Messrs. West, A. W. A. Brown, Wilkes and Prebble. Ably assisted by the officers of the Montreal Branch these committees produced one of the best programmes in the history of the Society, and a series of meetings fitting to the special occasion.

An interesting feature of the meetings was a beautifully prepared Commemorative Programme. This included an interesting account of the Montreal Branch and the Lyman Entomological Room, and a most intriguing "Entomologist's Strategical Guide to Montreal". The cost of production of this souvenir programme was met by the Lyman Entomological Bequest. Following is the programme of the meetings.

A BREATHING SPELL

The following poem was written in commemoration of the Seventy-fifth Anniversary of the Society by Mr. F. J. A. Morris, one of the old and active members of the Society. It is reprinted here in commemoration of the Seventy-fifth Anniversary of the Montreal Branch.

Four score but five of years so fleet
Give pause to round another bend,
A rallying-place for friends to greet
Ere onward once again we wend.

I.

A gallant flood of noble sweep
Our stream holds bravely on its course,
With sparkling face and limpid deep
That draws from rills beside the source.

A varied scene its banks display
In wood and swamp and far ravine;
By mill and farm it makes its way,
By garden-plot and pasture green.

All honour then to those before
Who pointed first the distant goal;
From hill to dale who steadfast bore
To trace the course our waters roll.

With outlook wide, from upland slope,
Our fathers viewed all Nature's ground;
We strive within a smaller scope
To perfect out our little round.

II

Children at play upon the shore
Of a mysterious, murmuring sea—
But gathered shells is all our lore,
The vaunt of poor humanity.

'Mid doubt and error on we go,
By glimmering star a path we steer;
To seek the truth but not to know,
The lot of all who voyage here.

We have our moments rich and rare
Amid long hours of darkest night,
When on our vision bursts the glare
Of meteor's trail or Northern Light;

Till comes with dawn the lookout's call,
Strange ships beat up by wind and lee,
In one great quest adventurers all
We sail no more a lonely sea.

III

Within the heart's all-cherished shrine
Of talents manifold are three
That Nature's mysteries best divine—
Love, Reverence and Humility.

In earnest work, in eager play,
By Nature-love united all,
With might and main do what we may,
Nor boast the great, nor scorn the small.

"So much to do, so little done"
Each lonely labourer's parting sigh,
Then speed the work so well begun,
The common purpose cannot die.

Each has his place within the plan,
His proper place none else may fill;
In brotherhood our course began,
By brotherhood is furthered still.

Then onward once again we wend
From rallying place for friends to greet,
From pause to round another bend
Four score but five of years so fleet.

FRANK MORRIS

PROGRAMME

TUESDAY, NOVEMBER 2nd.

LYMAN ENTOMOLOGICAL ROOM, REDPATH MUSEUM,
McGILL UNIVERSITY

7.00 p.m.
Meeting of Directors

8.00 p.m.
Meeting of Council

WEDNESDAY, NOVEMBER 3rd.

ASSEMBLY HALL, MEDICAL BUILDING
McGILL UNIVERSITY

9.00 a.m. to 10.00 a.m.
Registration of members and visitors

10.00 a.m.
Business Session:
Report of Council
Financial Report
Appointment of Committees

11.00 a.m.
Addresses of welcome:
Dr. F. Cyril James, Principal and Vice-Chancellor, McGill University.
Dr. W. H. Brittain, Vice-Principal, Macdonald College of McGill University.
Presidential address:
Dr. G. M. Stirrett, Kingston, Ont.
"The History of the Montreal Branch" – G. A. Moore, Montreal, P.Q.
"The History of the Society with Particular Reference to the Relationship of the Montreal Branch" – A. W. Baker, Guelph, Ont. (delineascope)

12.30 p.m.
Luncheon.

2.00 p.m.
"The International Congress of Entomology in Sweden and the Commonwealth Conference of Entomologists, London, England"–H. G. Crawford, Division of Entomology, Ottawa, Ont.
"The Cytological Separation of Buprestids" – S. G. Smith, Forest Insect Laboratory, Sault Ste. Marie, Ont. (P. 2″ x 2″)
"Testing for Aphid Resistance in Potatoes"–Leo A. Dionne, Dominion Entomological Laboratory, Fredericton, N.B.
"Preliminary Notes on pH Trends in Potato Foliage – R. H. Bradley and J. B. Adams, Dominion Entomological Laboratory, Fredericton, N.B. (L.4″ x 3¼″)

"Soil pH and Intensity of *Phyllophaga* Infestation" – G. H. Hammond. Division of Entomology, Marmora, Ont.

"The Apple Maggot Situation in Quebec District," – J. I. Beaulne, Province of Quebec, Plant Protection Division, Quebec, P.Q. (Read by title)

"The Influence of Spray Programs on the Fauna of Apple Orchards in Nova Scotia: III The Mite Fauna" – F. T. Lord, Dominion Entomological Laboratory, Annapolis Royal, N.S. (L. 3¼" x 4")

SYMPOSIUM

Orchard Control Methods

Chairman, W. A. Ross

5.30 p.m.

ROOM 212, SECOND FLOOR BIOLOGICAL SCIENCES BUILDING (near Medical Building). Demonstration by Dr. J. Stanley, Department of Zoology, McGill University, of mechanism for automatic sampling insect populations.

8.00 p.m.

CERCLE UNIVERSITAIRE, 515 Sherbrooke Street East, Entomologists' Smoker.

THURSDAY, NOVEMBER 4th.

UNIVERSITY OF MONTREAL

2900 MOUNT ROYAL BOULEVARD

Assemble Hall of Honor, main Entrance

ROOM H 404

9.30 a.m.

Address of Welcome, Monseigneur Olivier Maurault, Rector of the University of Montreal.

"Notes on *Pineus pinifoliae*, Fitch, and its Effect on White Pine" – R. E. Balch and G. R. Underwood, Dominion Entomological Laboratory, Fredericton, N.B. (L.3¼" x 3 1/4" Koda. 35mm)

"The Leconte Sawfly in the Province of Quebec (*Neodiprion lecontei Fitch*)" L. Daviault, Bureau of Entomology, Department of Lands and Forests, Quebec, P.Q. (P. 2" x 2")

"Forest Insects Introduced from Europe to the Maritime Provinces of Canada" – W. A. Reeks, Dominion Entomological Laboratory, Fredericton,, N.B. (Koda. P. 35mm)

"The Effect of Flowering Balsam Fir on Spruce Budworm Populations" – J. R. Blais, Forest Insect Laboratory, Sault Ste. Marie and the Department of Zoology, University of Toronto.

"The Role of Bark Beetles and Wood Borers in the Death of Balsam Fir Trees Severely Defoliated by the Spruce Budworm" – R. M. Belyea, Forest Insect Laboratory, Sault Ste. Marie and the Department of Zoology, University of Toronto.

"The Present Status of Entomology in France" – Rev. O. Fournier, Department of Entomology, University of Montreal.

ROOM H 404

11.00 a.m.

"Les Charançons de l'Orme et la Maladie Hollandaise" – Brother Adrien Robert, c.s.v., Department of Entomology, University of Montreal, and L. Daviault, Quebec, P.Q. (L. 3¼" x 4")

SYMPOSIUM
The Dutch Elm Disease
Chairman, W. N. Keenan

12.30 p.m.

Group photograph, Hall of Honour, Main Entrance.
Luncheon – University Cafeteria.

ROOM H 404

1.30 p.m.

INSECTICIDES

"Control of the Arctic Blackfly in the Saskatchewan River by DDT Applied from Aircraft" – A. W. A. Brown, University of Western Ontario, London, Ont. (with A. P. Arnason, F. J. H. Fredeen, W. W. Hopewell and J. G. Rempel). (P. 2" x 2")

"Warble Fly Control Studies in Ontario" – A. W. Baker, Department of Entomology, Ontario Agricultural College, Guelph, Ont.

"Preliminary Experiments with Parathion as an Insecticide and Acaricide" – G. G. Dustan, W. G. Garlick and T. Armstrong, Dominion Fruit Insect Laboratory, Vineland Station, Ont.

"The Chemical Control of the Tobacco Hornworm in Ontario" – C. J. S. Fox, Dominion Entomological Laboratory, Chatham, Ont.

"Preliminary Notes on Corn Borer Investigations in New Brunswick in 1948" – D. D. Pond, Dominion Entomological Laboratory, Fredericton, N.B.

"Residual Action of Low Vapour Pressure Fumigants" – B. N. Smallman, Dominion Entomological Laboratory, Winnipeg, Manitoba. P. 2" x 2")

"Comparison of Calcium Arsenate, Chlordane and DDT for the Control of Potato Insects" – J. Duncan and J. A. Doyle, Province of Quebec, Plant Protection Division, Quebec. (Read by title)

SYMPOSIUM
Entomological Education
Chairman, R. E. Balch

6.30 p.m.

ANNUAL BANQUET (Informal) Faculty Club, McGill University, 3450 McTavish Street, Montreal, P.Q.
H. A. U. Monro, Chairman.
Guest speaker: Dr. J. Stanley, Professor of Zoology, McGill University, "A Biologist Looks to the Future".

FRIDAY, NOVEMBER 5th.

UNIVERSITY OF MONTREAL

2900 MOUNT ROYAL BOULEVARD

ROOM H 404

9.30 a.m.

"An Artificial Food for Rearing *Pseudosarcophaga affinis* Fall. a Parasite of the Spruce Budworm" – H. L. House, Dominion Parasite Laboratory, Belleville, Ont.

"Developments in the Biological Control of the Larch Casebearer, *Haploptilia laricella Hbn.*" – A. R. Graham, Dominion Parasite Laboratory, Belleville, Ont.

"The Control of the European Spruce Sawfly by a Virus Disease in Endemic Populations" – F. T. Bird, Forest Insect Laboratory, Sault Ste. Marie, Ont. (L. 3¼" x 4")

"An account of visits to Mite Collections in Europe" – H. H. J. Nesbitt, Division of Entomology, Ottawa.

"A Note on the Distribution of *Mantis religiosa* L. in Ontario" – H. G. James, Dominion Parasite Laboratory, Belleville, Ont. (L. 3¼" x 4")

"Observations on the Outbreak and Control of the Japanese Beetle at Halifax, N.S." – R. G. Webber, Plant Protection Division, Halifax, N.S.

"The Potato Aphid Survey 1948" – M. E. MacGillivray, Dominion Entomological Laboratory, Fredericton, N.B.

"The Potato Leafhopper Distribution in Eastern Quebec" – P. E. Mercier, Province of Quebec, Plant Protection Division, Quebec. (Read by title)

11.00 a.m.
Final Business Session.

12.30 p.m.

Luncheon – University Cafeteria.

1.00 p.m.

Tour of University of Montreal Buildings, conducted by Rev. O. Fournier.

2.00 p.m.

Departure for Field Trips:

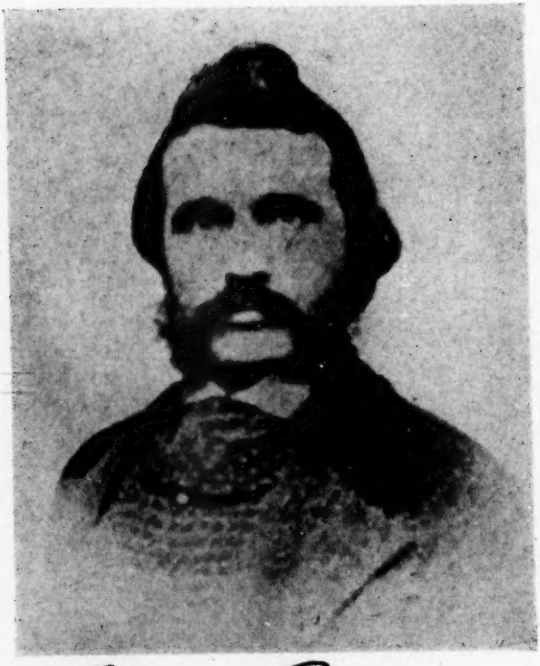
A. The Chalet, Morgan Arboretum, Morgan's Woods, near Macdonald College, P.Q. Host, Dean W. H. Brittain. Property containing 500 acres of woodland recently acquired for biological studies.

B. Fumigation Plant and Laboratory, Department of Agriculture, Plant Protection Division, 785 Mill Street, Montreal, P.Q.

C. Science Service Laboratory, Saint Jean, P.Q.

D. Visit to Dutch Elm Disease outbreak, Westmount, P.Q.

E. Montreal Botanical Gardens, 4101 Sherbrooke Street East.



J. M. Cooper

HISTORY OF THE MONTREAL BRANCH OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO

Geo. A. Moore

The Montreal Branch of the Entomological Society of Ontario, passed its seventy-fifth anniversary on October 16th, but did not hold a special meeting on that date as we had anticipated it at our annual meeting on May 15th and had previously invited the Parent Society to hold their annual meeting in Montreal as a Commemorative Anniversary Celebration. When our invitation was accepted we were pleased, and we greet you here, and trust you will enjoy meeting with us at the three Institutions that have aided us greatly in our pursuit of Entomology, namely, McGill University, Université de Montreal and Macdonald College.

You have no doubt already read the brief accounts of our history, and that of the Lyman Entomological Room in our Commemorative program.

Looking back over the history of seventy-five years, both from our own experiences, and from the minute books of the Branch, we see a line of enthusiastic naturalists and entomologists who were fired by a deep love of nature, and particularly of Insect life, and who have left behind them records of their study in articles printed in our magazines and in lists of our fauna. Their history is also recorded in the Lyman Entomological collections, which contain the life work of many of our present and former members. These collections contain the specimens of Lepidoptera accumulated by Messrs. H. H. Lyman, A. F. Winn, E. Denny, G. C. Dunlop, G. W. and G. B. Pearson, W. Couper, T. D. Brainerd, L. Gibb, R. C. Holden, A. C. Sheppard and others; the Coleoptera accumulated by G. Chagnon and G. Beaulieu the varied collections of Dr. T. W. Fyles and Dr. A. Willey; the Hymenoptera of J. Buckle and the Hemiptera from Geo. A .Moore, and an examination of the cabinets will reveal many other individual specimens, formerly belonging to members of our Branch. You can follow them from the labels throughout the Province, from east to west, and north to the limits of life. A story told of the indefatigable search for every species located in our territory.

The Branch had its origin in a chance meeting of five entomologists who were collecting on our Mt. Royal in the summer of 1873, who, after a discussion, decided to meet at the residence of Mr. F. B. Caulfield to consider the formation of an Entomological Society. The meeting was held on Saturday, Aug. 30th, 1873, when according to the minutes, the Chairman, Mr. Wm. Couper stated that the object in forming this Branch was to bring together the scattered workers in our branch of Natural Sciences, so that the result of their labours might be known to all; to hold monthly meetings for the purpose of reading papers on Entomological subjects, exchange of specimens, etc. The Secretary pro-tem was instructed to write to the Entomological Society of Ontario, requesting permission to form a branch society.

On October 16th, 1873, the entomologists were called together to consider the reply received by the Secretary pro-tem, and to organize themselves. A letter received from Mr. J. Williams, Secretary of the Entomological Society of Ontario, stated that at their Annual meeting, the proposal to form a branch society was unanimously accepted.

Those constituting the original members were: Messrs. Wm. Couper, M. Kollmar, P. Keutying, C. W. and G. B. Pearson, C. J. Bowles, F. B. Caulfield, W. Hibbins, and W. Hibbins, Jr. The election of Officers resulted in the following being elected:—

President	Wm. Couper
Vice President	M. Kollmar
Sec. Treas.	F. B. Caulfield
Curator	W. Hibbins, Jr.
Council	G. J. Bowles, P. Keutying, C. W. Pearson

Bylaws were drawn up, and these were officially approved on Nov. 11th, 1873.

So began the Montreal Branch which has met regularly throughout the seventy-five years of its existence, and held their 613th meeting on May 15th of this year. The average attendance during the full period was seven members per meeting, but for the last ten years the average has increased to twelve and one half (12½) per meeting. Only on a few occasions were the meetings reduced to two members, but as all entomologists know, two entomologists can make a meeting, where they can discuss their mutual studies

During its existence 1015 papers have been read on all kinds of entomological topics, an average of 13½ papers each yearly session.

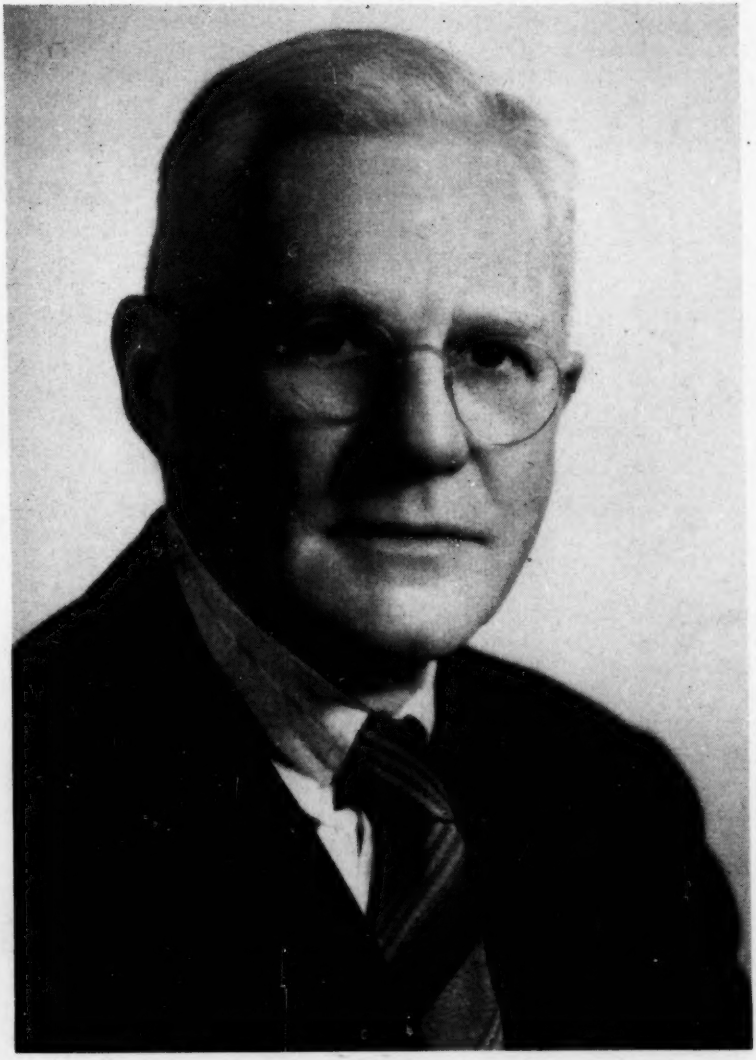
I attach to this paper for historical purposes the names of all who have been members of our Branch since its beginning up to date. They total 171.

I also include the names of those who have been officers, the dates of their service and total years of service.

For the first forty-three years until 1916, the Branch held its meetings at the residence of members, where a social time was usually spent after the close of the meeting. When I joined in 1896, Mr. Lyman was having the meetings at his home on McTavish Street, which he continued until the year 1910. Since that time most of our meetings have been held in the Lyman Entomological Room, Redpath Museum, with occasional meetings at the Université de Montreal, and Macdonald College. At these places our members have access to Entomological collections and Libraries, from which they have been able to enlarge their experiences.

In the early days most of the members were Lepidopterists, but later Coleoptera, Hemiptera, Diptera, Hymenoptera, Odonata and Trichoptera were studied by other members. Lately a large number of members are engaged in economic work in the service of either the Provincial or Federal Departments of Agriculture. This has unfortunately decreased to some extent the enthusiasm and interest formerly manifested by the Amateurs, as when Entomology becomes professional, the out of work time is being spent on other interests than that of one's day's work.

The early days brought into prominence men who were lovers of nature, and who did not confine themselves to one class of Animals or Plants. All nature spoke to them, and they became familiar with the birds and flowers as well as the Insects, and their pursuits filled their lives with interest and wonder. Those who were strictly Enomologists found pleasure in collecting the local fauna, and working out life histories. Many a col-



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lection disappeared after the Entomologist passed to his reward, but the pleasure experienced and the knowledge gained was worth the effort made. Many collections, however, were saved as has already been mentioned through Mr. Lyman's generosity and farsightedness, in establishing the Lyman Bequest which I will refer to again later in this paper.

The twenty-fifth Anniversary was celebrated on November 9th, 1898, in the old National History Society's museum on University Street when the Entomological Society of Ontario held their 35th Annual meeting in Montreal. It took the form of a conversazione, at which an orchestra played music and refreshments were served. There was an exhibition of Lepidoptera, and the Microscopical Society exhibited a number of interesting and beautiful objects under miscroscopes. The late Rev. Dr. Bethune and the late Dr. Fletcher addressed those present.

The 50th Anniversary passed without special meetings. Mr. Winn was very ill at the time and the Parent society could not hold their Annual meeting in Montreal that year.

Our members have contributed many articles to Entomological magazines, especially the Canadian Entomologist, too many to be mentioned here, but the result of their work and research is there for all time.

Our members have been active in the welfare of the Parent Society, the Entomological Society of Ontario, and three of our members have been President, namely Messrs. H. H. Lyman, A. F. Winn and Geo. A. Moore. Others have held positions as Directors and Counsellors.

Our members have also been active in other Societies, such as the Quebec Society for the Protection of Plants, the Entomological Society of America, the American Association of Economic Entomologists and the Royal Society of London, England.

Like all societies, we have had many come to our meetings who have had only a passing interest in Entomology, but there has always been a nucleus of enthusiastic entomologists who have collected insects, studied and identified them, written papers describing their discoveries, assisted the beginners, and given information and service to the general public.

Each year outings are organized to nearby good collecting grounds, especially on May 24th, if weather permits, when we officially open the season.

Now allow me to make some short remarks about a few of our members.

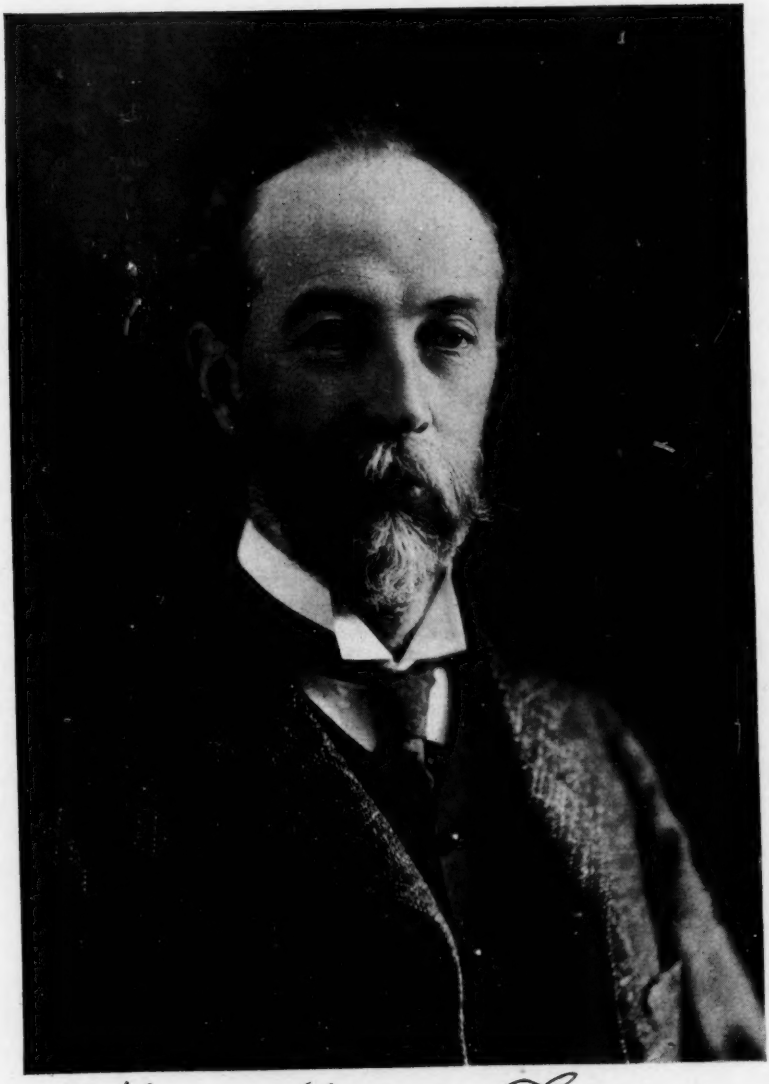
Our first President, Mr. William Couper, was an enthusiastic naturalist, and wherever he was located gathered around himself other nature lovers. He was, therefore, with the first group of entomologists to organize in Montreal, and he continued with them as long as he lived here. He wrote many papers on natural history and entomology, and had his papers published in different magazines, one of which was our Canadian Entomologist. He was also editor and publisher of The Canadian Sportsman and Naturalist. He left Montreal in the year 1884 for New York, and the last record of him was in the New York Directory of 1886. It is thought he died in 1890 at his son's residence at Troy, N.Y.

Mr. H. H. Lyman was one of our distinguished members. He became a member two years after the Branch was organized that is in the year 1875. He was a serious student of Lepidoptera and gathered together a

large collection, particularly of North America. He wrote and published many articles, and was constantly in touch with all the authorities on Lepidoptera. He was internationally known and was a regular attendant at the meetings of the Parent Society and was President from 1898-1900 and President of the Montreal Branch for a period of fifteen years. He also attended the meetings of the American, British and the International Conventions. Mr. Lyman was seriously afflicted with deafness and had to use mechanical and electrical aids to hear, and even with them had difficulty in hearing what was said. Nevertheless, he never allowed it to interfere with his attendance at meetings, and appeared to thoroughly enjoy himself. He could read the papers submitted and used paper notes to facilitate his intercourse. It was with a great shock that the members heard of his tragic death when the S.S. Empress of Ireland foundered in the St. Lawrence River on May 29th, 1914. Mr. Lyman had no desire that his valuable collection should be lost or dissipated, and had bequeathed it, and his Entomological Library to McGill University, with sufficient funds to maintain and enlarge it, on the condition that a separate room be designated the Lyman Entomological Room, and that a committee be formed to manage it. All this was agreed to and his collection and library were installed early in 1915. The original collection was housed in five cabinets of 30 drawers each, a total of 150 drawers. This has grown to 34 cabinets and 913 drawers, containing approximately 20,000 species and 200,000 specimens. The Lyman Entomological Room is used by the Montreal Branch for their meetings and we are very grateful for the benefit we derive from the library which has now approximately 1700 volumes, and the enlarged collection.

Mr. A. F. Winn became a member in 1888 and continued until his death in 1935. Mr. Winn was also a student of Lepidoptera and became an authority and accumulated a large collection, which is now incorporated into the Lyman collection. He also prepared and published many articles of his favorite study in the Canadian Entomologist. He was very helpful to beginners, and was the person who invited me to join the Society. He was President of the Branch for 15 years and of the Parent Society for two terms 1915-1916 and 1916-1917. He took charge of the Lyman Collection at the beginning and acted for 21 years. From 150 drawers of insects, he increased it to over 900 and started collections of all the other Orders of insects, so that we now have a very representative collection of all our North American insect fauna.

For historical purposes I give herewith a short account of my own connection with the Branch. I became a member in 1896 through an invitation from Mr. Winn and have continued without lapse for 52 years. I have been President of the Branch at different periods totalling 25 years and was President of the Parent Society 1944-1945. In 1945 I was made Honorary member of both the Parent Society and Branch. I am a member of the American Association for the Advancement of Science, The Entomological Society of America, and a fellow of the Royal Entomological Society of London, England. I have been Curator of the Lyman Entomological Room since Mr. Winn's death in 1935. I have published several articles on my special subject, the order Hemiptera, and have ready for publication a list of the Hemiptera of the Province of Quebec.



Henry Herbert Lyman
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Mr. G. Chagnon joined the Branch in 1899 and is therefore one of the members with a long membership. He was made an Honorary Member of the Parent Society and also of the Branch in 1945. Mr. Chagnon is an authority on Coleoptera and Diptera and has published a list of the Coleoptera of the Province of Quebec. He has also published many articles, and several works. Amongst these are "Contribution à l'étude des Coleopteres de la Province de Quebec," "Contribution à l'étude des Orthopteres et des Dermatids de Quebec," "Les Tabinades de Quebec" and several others.

Mr. H. A. U. Monro who is chairman of the Local Committee in charge of this year's Annual meeting became a member in 1934, and was President of the Branch in 1937. He is attached to the Federal Entomological Service.

Mr. A. C. Sheppard, our present Secretary, has been a member since 1918 and is one of our prominent Lepidopterists.

Abbé O. Fournier has been a member since 1935. He is head of the Department D'Entomologie at the Université de Montreal and is an active Entomologist, teacher and leader.

The following gives a few details regarding several of our present members:—
Bro. J. Ouellet and Bro. A. Robert are both active students of Coleoptera, Diptera and Hemiptera.
Dr. G. Fisk has had considerable experience with insect borne diseases.
Dr. E. Munroe is a specialist in Lepidoptera.
The following are Economic Entomologists attached to Governmental Entomological Divisions:—Messrs. W. St. G. Ryan, N. P. Beaudoin, N. Cameron, C. E. Petch, J. B. Maltais, A. A. Beaulieu, J. E. King.

The information I have just given you is largely that of names, dates and records, which are but the bare skeleton of what our Society was and is today. It is a body of human beings having an interest in the world of nature, and bound together with a common interest in the Insect World. It is and has been a fellowship of kindred spirits, and a group who cooperates with each other, and who are ever mindful of their fellow members when away on vacations and who bring back specimens of other orders to enhance collections other than their own.

In 1973 we will reach 100 years of existence. The intervening years will no doubt bring many changes, but I believe the Entomological group will continue, and will add to the knowledge of our fauna, and assist in the solutions of problems relating to nature and to the well being of the human race.

OFFICERS OF THE MONTREAL BRANCH OF THE ENTOMOLOGICAL SOCIETY OF ONTARIO FOR THE SEVENTY-FIFTH ANNIVERSARY YEAR

President:	Geo. A. Moore
Vice-President:	Rev. Abbé O. Fournier
Secretary-Treasurer	A. C. Sheppard

Council members:

G. H. Fisk, E. R. Bellemare,
H. A. U. Monro, E. Munroe,
J. B. Maltais, A. A. Beaulieu.

COMPLETE LIST OF MEMBERS OF MONTREAL BRANCH WITH DATE OF ELECTION

O—original member
V—served as Vice-President
P—served as President
S—Served as Secretary-Treasurer

VS	Adams, W. C.	1889
	Allaire, Bro. G. H.	1946
	Andres, S. J.	1879
	Barnes, T. C.	1920
	Barwick, E. C.	1904
	Beaudoin, N. P.	1936
	Beaulieu, A. A.	1942
	Beaulieu, C.	1899
	Beaulne, J. I.	1910
	Bellemare, E. R.	1939
	Bishop, Margaret	1930
S	Bowles, C. H.	1878
OPVS	Bowles, C. J.	1873
V	Brainerd, T. D.	1896
	Brainerd, H.	1896
	Breitenbecker, J. K.	1926
	Brittain, W. H.	1909
	Brunelle, Miss L.	1946
S	Buckle, J. W.	1919
	Burland, R.	1881
	Cam, W. C. P.	1931
	Cameron, N.	1936
	Campbell, R.	1910
	Carland, G.	1916
	Carmichael, Rev. C.	1884
	Carsley, J. L. G.	1921
OVS	Caulfield, F. B.	1873
PV	Chagnon, G.	1899
	Chambers, E. T.	1896
	Chandler, A. G.	1896
	Chisnell, S. C.	1931
	Clark, M. M.	1921
	Clayson, G. H.	1912
	Conway, J.	1921
	Copland, P. F.	1894
	Corcoran, J. A.	1916

OPV	Couper, W.	1873
	Cowan, K. M.	1898
	Craig,, Mrs.	1882
	Craft, T. H.	1931
	Cuerrier, J. P.	1940
	Cummings, R. F.	1916
	Cushing, H. B.	1890
	Cushing, J. W.	1891
	Dansereau, P.	1944
	Darling, H. M. E.	1909
	Davidson, M.	1874
	Davis, M. W.	1898
	Dawson, P. M.	1894
	Delisle, H. M.	1909
	Delisle, R.	1940
	Denny, A.	1903
	Denny, E.	1901
	Denton, F.	1940
	Dunlop, W. W.	1882
	Dunlop, G. C.	1894
	Earby, A.	1910
	Earle, H.	1876
	Edwards, G. M.	1889
	Elliott, W. R.	1899
	Ernest, Bro.	1941
	Fantham, H. B.	1934
	Fisk, G. H.	1925
	Fisk, Mrs. G. H.	1925
	Fortin, Miss B.	1944
	Fosberry, C. S.	1906
V	Fournier, Rev. O.	1935
	Fyles, Rev. T. W.	1874
	Fyles, Rev. W. A.	1899
	Gauthier, C.	1940
	Gerth, W. G.	1909
V	Gibb, A.	1874
	Gibb, E. M.	1894
VS	Gibb, L.	1874
	Graves, H.	1882
	Green, H. V.	1946
	Grey, P. H. H.	1945
	Grieve, Mrs. E. C.	1937
	Griffin, A.	1890
V	Hall, C. H.	1917
	Haliburton, W.	1936
	Hart, O. C.	1894
	Hausen, J. F.	1885
	Henderson, G. M.	1913
O	Hibbins, W.	1873
O	Hibbins, W. Jr.	1873

	Hindle, W.	1931
	Holden, Alb.	1883
	Huot, L.	1945
	Jack, J. L.	1882
V	Jack, J. S.	1874
V	Jack, Robt.	1874
	Jackson, Chas.	1889
	Jackson, E. S.	1917
	Johnston, W.	1905
	Johnston, W.	1903
	Kearley, C.	1874
	Kenyon, H. F.	1918
	King, D.	1947
	King, J. E.	1948
	Kollmar, E.	1906
OV	Kolllmar, E.	1873
O	Keutying, P.	1873
	Labelle, Miss S.	1945
	Leymaire, S. H. A. L.	1901
	Lochhead, W.	1907
	Love, W. J.	1929
PV	Lyman, H. H.	1875
	Major, R.	1948
	Maltais, J. B.	1938
	McLennan, K.	1878
PS	Monro, H. A. U.	1934
PVS	Moore, G. A.	1896
	Moore, I.	1874
	Morrison, F. O.	1938
	Mousley, H.	1925
	Muir, Miss I.	1920
	Munroe, E.	1934
	Newman, C. S.	1900
PV	Norris, A. E.	1895
	Ouellette, Bro. J.	1909
	Parker, J.	1920
	Parkins, F.	1909
	Peden, F. K.	1920
OS	Pearson, C. W.	1873
OVS	Pearson, G. B.	1873
	Petch, C. E.	1931
	Poirier, E. E.	1916
	Porter, A.	1934
	Pye, H. T.	1896
	Raynault, L.	1945
	Reed, G.	1909
	Reford, L.	1896
	Riddle, Jas.	1895
	Rioux, C.	1945
	Robert, Bro. A.	1945

	Robinson, S.	1904
	Rowland, A.	1909
	Ryan, W. St. G.	1936
	Rybnicek, G.	1947
	Sach, C. W.	1907
	Shaw, W. D.	1881
S	Sheppard, A.	1918
	Shield, Rich.	1881
	Simms, H. M.	1914
	Smith, S. G.	1942
	Sneith, W. H.	1894
V	Southee, G. A.	1908
P	Southee, G. R.	1903
	Sperling, G.	1946
PV	Stevenson, Chas.	1900
	Stewart, G. M.	1906
	Sunderland, H.	1911
	Swaine, J. M.	1907
	Symonds, Rev.	1907
	Tache, P.	1948
	Terril, L. M.	1919
S	Trenholme, E. R.	1888
	Vladykov, V.	1941
	Walter, J.	1914
	Warren, J.	1922
	Warren, W.	1922
	Warren, W. R.	1878
	Weir, D.	1907
	Whitehead, W. E.	1948
	Willey, A.	1918
	Williams, J. B.	1895
	Wilson, A. C.	1919
	Wintle, E. D.	1881
	Wintle, G.	1900
PVS	Winn, A. F.	1888
	Wood, Rev. E.	1899

OFFICERS OF THE MONTREAL BRANCH

Presidents

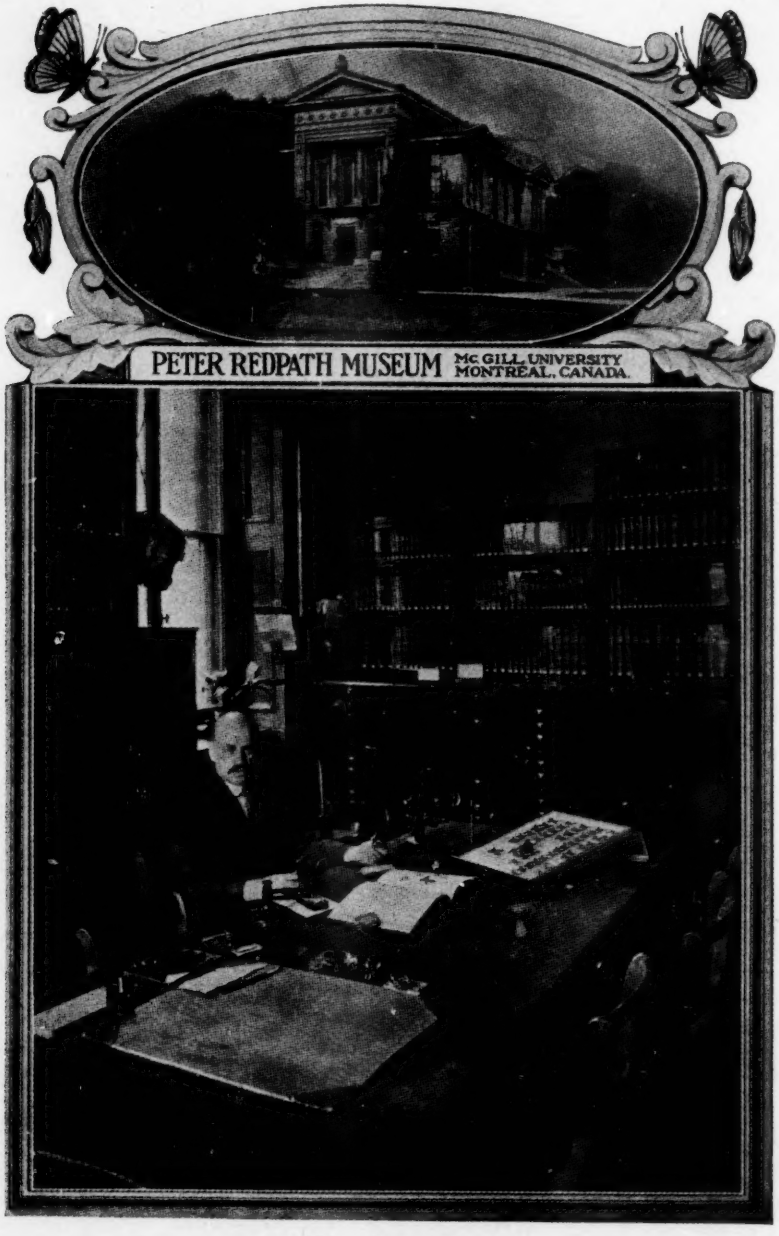
W. Couper	1873-74
J. G. Bowles	1875-80
	1883-87
H. H. Lyman	1881-82
	1888-98
	1909-10
A. F. Winn	1899-1900
	1913-22
	1931-33
Geo. A. Moore	1906-08
	1923-33
	1934-36
	1938-48
G. Chagnon	1901
C. Stevenson	1902-03
A. E. Norris	1904-05
G. A. Southee	1911-12
H. A. U. Monro	1937

Vice-Presidents

M. Kollmar	1873
G. J. Bowles	1874
Alex. Gibb	1875
F. B. Caulfield	1876
	1888-91
H. H. Lyman	1877
	1879
	1885-87
	1908
Rob. Jack	1878
G. B. Pearson	1880
W. Couper	1881-83
J. G. Jack	1884
W. C. Adams	1892
L. Gibb	1893-94
A. F. Winn	1895-98
D. Brainerd	1899-1900
	1903-04
C. Stevenson	1901
A. E. Norris	1902
Geo. A. Moore	1905
E. C. Barwick	1906-07
G. H. Southee	1909-10
G. Chagnon	1911-22
	1934-37
G. H. Hall	1923-33
Rev. O. Fournier	1938-48

Secretary-Treasurers

F. B. Caulfield	1873-74
	1884-87
E. W. Pearson	1875
G. B. Pearson	1876-78
G. H. Bowles	1879-81
G. J. Bowles	1882-83
E. C. Trenholme	1888-89
A. F. Winn	1890-93
	1905-12
W. C. Adams	1894
L. Gibb	1895-1900
Geo. A. Moore	1901-04
	1913-22
J. W. Buckle	1923-36
A. C. Sheppard	1937-
	1946-48
H. A. U. Monro	1938-45



ALBERT F. WINN
in the
Lyman Entomological Room

LYMAN ENTOMOLOGICAL COLLECTION AND LIBRARY

Lyman Room, Redpath Museum.

McGill University

This collection was donated to McGill University by the will of the late Henry H. Lyman. It contained the collection of Lepidoptera, chiefly of North America, made by Mr. Lyman during his life time.

Mr. Lyman was drowned on May 29th, 1914, and, in accordance with his wishes, the Lyman Bequest Committee was appointed to manage the bequest and arrange for the maintenance and extension of the collection and library. Its first meeting took place on December 22nd, 1914, and a yearly meeting has been held since. The first Committee was under the Chairmanship of the late Dr. A. Willey and included the late Dr. C. Gordon Hewitt, Dominion Entomologist, the late Mr. A. F. Winn and Mr. Geo. A. Moore of the Montreal Branch of the Entomological Society of Ontario. Mr. Moore was appointed Secretary and has continued in that office up to the present time.

Dominion Entomologists who have served on the Committee have been: the late C. Gordon Hewitt, Dr. A. Gibson, the late Dr. L. S. McLaine and Mr. H. G. Crawford. Other members of the committee have been as follows: representing McGill University, the late Dr. A. Willey and the late Dr. F. B. Fantham, Dr. N. J. Berrill, Dr. John Stanley and Principal Dr. C. F. James; representing Macdonald College, the late Dr. W. Lochhead and Dr. W. H. Brittain; representing the Montreal Branch, the late Mr. A. F. Winn and Mr. Geo. A. Moore.

Mr. Winn acted as curator until his death on July 3rd, 1935, when Mr. Moore was appointed to succeed him. Mr. Lyman's collection was housed in five cabinets with 150 drawers. Under Mr. Winn's care, the collection became a general one including all orders of insects, and increased in number bringing the total to date to 34 cabinets with 913 drawers. The largest number of specimens belong to the order Lepidoptera, but all other orders are represented.

The library has now approximately 1700 volumes, including a wide range of books on Entomology and sets of most of the Entomological magazines.

The room is not open to the general public, but appointments are made for those who wish to see the collection. Students of McGill University, Macdonald College and the University of Montreal, use the room for entomological study and students of entomology from all parts of the world have called in to make special studies. The library is also used by the inter-college loan system.

The curator answers all queries made by the general public on entomological matters.

In addition to Mr. Lyman's collection, those of Mr. Winn, Dr. Willey, Mr. L. Gibb, E. Denny, G. Chagnon, J. Buckle and Geo. A. Moore, are now included in the general collection, which now contains approximately 20,000 species and 200,000 specimens.

A BIOLOGIST LOOKS TO THE FUTURE

DR. J. STANLEY.*

When our genial chairman, Mr. Monro, asked me to speak here tonight, I accepted with rather mixed feelings. I accepted with pleasure because I knew I should meet here many old friends, some of whom date back even to my undergraduate days. I accepted with some measure of diffidence because I am not really an entomologist, and there was always the risk that some of you, particularly those few who were once my students, might find out how little I really know about the subject.

An entomologist is one who knows a lot about a restricted group of animals, while a teaching zoologist knows a little about a wider group of beasts, so I decided to choose a subject in which I am myself much interested, and one on which I cannot be checked up for some time to come. I hope that in the case of my former students I shall not display too much evidence of academic clay in my tarsi.

I wish to speak to you this evening on the subject of the possible future of the biological sciences, and to discuss their possible impact upon Man and his civilization.

We live today in a highly materialistic world, owing its general lushness in no small degree to a liking for gadgetry, and this in turn stems from the enormous rise of the physical sciences, and of chemistry and engineering. These have provided the framework in which we live, and incidentally have provided us with the tools to wage our periodic wars. The man in the street generally realises his indebtedness to these sciences and shows it by more or less generous support of them.

It is less generally realised, I think, that it is the biological sciences which make it possible for man to survive in his world of machines, wires and gadgets. Long ago Malthus predicted that we would run out of food owing to the rapid increase in our numbers. As a matter of fact, the world population did increase much faster than Malthus had predicted, due to the rise of Medical Science, but the other biological sciences, agriculture in all its branches, economic entomology and the like, made this increase possible without the accompanying famine, notably aided by the opening up of new lands which made great contributions to the world food supply.

This is something almost unrealised by the common man. He recognises the value of medical work because it has no doubt had some impact on himself or upon his family, but most of the rest he takes for granted, because after all, except in unusual times, there is always food available, and fibres for textiles to clothe him.

This lack of understanding is also partly due to the fact that the achievements of biologists seldom result in loud bangs, hardly ever kill anybody, and do not result in intriguing gadgets. Thus they are not spectacular to the ordinary man, who has now become pretty hardened to "colossal", "terrific", "amazing", and other adjectival happenings around him.

Thus it comes about that while the larger public interest is centred upon the results of activities in the more physical sciences, there exists an enormous and comparatively unknown background of work in the biological sciences, making it possible to feed, clothe, and maintain ourselves in the world which the physicists and engineers have given us.

We have arrived at this position partly also, due to the very long period of time which, in the case of the more formal biological sciences

* Professor of Zoology, McGill University.

has had to be spent on a preliminary study of our materials, i.e., on the fundamental studies of taxonomy and comparative anatomy. Essential and fundamental though these are, they do not lend themselves to public interest, and are not easily understood in a newspaper sense.

It is only comparatively recently that we have been able to get sufficiently far advanced with this phase to branch out into other fields, and so begin to attack some of the fundamental problems of life itself, both in the single animal and plant, as well as concerns groups and associations of living beings. It is undoubtedly along these lines that our greatest contributions will be made in the future. Let us then speculate as to some possible developments.

Let us, as a preliminary, turn our eyes backward some 400 to 500 million years. This earth was not then as we know it now. The very seas and continents with which we are so familiar had not yet been laid down, and through a humid and oppressive air a blazing sun shone down on a hot silent and lifeless world.

We do not know, and can never know for certain, how life first began. We may assume, if you wish, that in the fullness of time, and under the aegis of the laws of probability, there arose one day what has been called a "fortuitous concourse of atoms". This was of sufficient complexity to be able to exhibit in some degree the peculiar characteristics of what we call *life*, and it was also able to reproduce, to make other groupings like unto itself. And so there began the endless chain reaction, culminating finally in ourselves.

So speaks the modern scientist, but if you prefer the beautiful words of Holy Writ, I will not quarrel with you: "And God said, 'Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his own kind, whose seed is in itself upon the earth and it was so'."

We are still in almost utter ignorance of what constitutes the state of being alive. No valid definition has ever been given, though many have been attempted. Nevertheless two things do seem to stand out, that living material is nearly always more complex in its structure than is non-living, and it seems to be able to defy the laws of probability. Left to themselves a group of moving black and white particles will nearly always be found equally distributed in a space, but if a living being is introduced into the system, the laws of probability at once break down, because the living being can sort the beads out. In this way, events which, in a non-living system might occur only once in a billions of years, can be made to occur at any time and in a few minutes in a living system.

This living being is however, made of electrons, protons and the like, as is everything else, and it would seem hard to explain its phenomenal powers unless it has also something in addition to the inanimate particles of which it is constructed. If this something which we call *life* is some intangible property, we may never be able to comprehend it or to create it. On the other hand, if it consists in some sort of special arrangement of the constituent particles, we may well at some time in the future, come to an understanding of it, and so be able to synthesize at least a simple living structure.

As a matter of fact we have already made an initial move in the exploration of such a possibility in the work of W. M. Stanley, who in-

cidentally is not related to myself. This able investigator showed that the virus of tobacco mosaic disease could propagate itself in the living tissues of a tobacco plant, and could also be crystallised and made to enter into chemical compounds as if it were a non-living chemical substance. Its operative particles, though no doubt of immense molecular complexity are not more complex than many other organic compounds, and so the possibility exists that we may some day be able to synthesize it. This is an intriguing thought. Supposing we did at some time make such a substance, atom for atom identical with the virus of tobacco mosaic. Would it be alive? My own feeling as a scientist is that it would, but I have also an uneasy feeling as a human being that it would not.

If the substance proved to be non-living, we should have a direct proof that the state of being alive is more than a matter of a particular organisation of elementary physical particles.

We are also today interesting ourselves more and more in the inner mechanics of living tissues themselves, as apart from the problem as to what constitutes the fact of being alive. In the past, much of the work in Botany, Zoology and Entomology concerned itself with the form and structure of dead animals. Now we are concerned with living tissues and animals.

The enormous rise of biochemical and physiological knowledge, particularly in recent years, and the increasing knowledge of enzymes, are beginning to give us some faint idea of the mechanism by which living materials operate and have their being. We are still largely in ignorance of how and why an enzyme works, but we are coming to understand a little of it, and perhaps at some time in the future, some Einstein of the biological world will give us a valid theory of enzyme action. This will unlock the door to vast fields of knowledge and make possible enormous advances in all fields of work having to do with living tissues. It will have an impact upon all the biological sciences from allergy to zoology. Eventually we may be able to create either by direct synthesis, or through the help of living materials, special enzymes for special purposes, and thus facilitate the easy manufacture of new and useful substances for medical use, textiles, foods and so on.

Concomitant of course with our increasing knowledge of why tissues live comes increasing knowledge of how to stop them living. This is useful today to the maker of weed killers and insecticides but the time may come unfortunately, when it may be turned to military uses. A substance which would affect the growth of human beings as 2-4-D does the dandelion would indeed be a fearful thing, while a synthetic virus might well plumb the depths of horror. Perhaps it is as well that these things are difficult. Perhaps when we have learned how to do these things, we shall also have some common sense.

Stepping a little higher up the scale, we are also greatly interested in bio-mechan cal details of a higher order of magnitude, such as the manner of operation of say the central nervous system. We have accumulated a vast fund of knowledge about the brain and mind, and there has recently been worked out a mathematical theory of the operation of the brain, which may or may not prove valid, but will certainly be useful. We are still in the

dark as to whether or not the mind as such is something superior to the brain, using the brain as an operative tool, or whether the mind is merely a result of the workings of the brain. This problem is in a way analogous to the question previously discussed as to whether life is or is not something beyond an arrangement of non-living particles.

Work in neurology and psychiatry would seem to indicate that the mind is the product of the working of the brain, since defects in the brain lead to aberrations of mind. We might equally well i suppose, consider the mind as an operator of the brain, faulty instruments leading to faulty operation.

This matter comes close to one of the old conflicts between religion and science. The proponent of religion insists on the reality of a soul, while the scientist insists that he cannot find any evidence of it. It is possible that both are right, differing only in outlook, and thus in what they see. Suposing we were to consider the life-force (or whatever you wish to call it) as something which is essentially impalpable to us in this space and time unless it can operate through a special arrangement of atoms and molecules. When and where such an arrangement exists it will provide an outlet for this force, and we shall say that the material lives. This is analogous to the production of music by a radio in a broadcast field.

If the degree of complexity of the would-be living system is low, the degree of expression of the living force is simple, and the tissue merely lives. If on the other hand, the complexity is higher, as in the association of tissues into organs, and organs into a man, the degree of expression is naturally more complex and rich, and we have the phenomena of consciousness of existence, thought, and so on.

Just as in a radio, some minor maladjustment may distort the tone, so in a living man, some defect of the machinery may give rise to mental aberrations, and a more severe defect may stop the machinery altogether, making it impossible as an outlet to this life force.

It inevitably follows from the above that the so-called soul of a man differs from the life force which operates an earthworm in degree but not in kind. Both draw their power from a single source, but because the instruments of expression and modulation of this force are more complex in the case of man, the expression and modulation are naturally more complex. I hope however, that no one will assume that I am trying to prove that earthworms have souls. Also I lay no insistent stress on a belief in this hypothesis, but if you will think about it, I believe you will find that it will explain a good many otherwise irreconcilable conflicts.

Passing now from the single animal to groups of animals. Interest in such is comparatively recent, stemming from the rise in ecology. When we began to investigate the relations between animals and their environment, we were inevitably led to a study of the relationshp between animal and animal. We thus came to see more clearly that animals and plants live in groups and associations and populations, and that these can even be thought of as super-entities of which the constituent individuals are the component parts, as our cells are part of our bodies.

This concept will, I believe, lead to notable advances in the future, but progress is likely to be slow for some time to come. The investigation of the actions and reactions of groups of animals requires a mathematical approach, and three difficulties at once arise.

First, many biologists who, for want of a better expression can be classified as "of the old school" decry the use of mathematics. They feel that it is inapplicable to the problems in hand, and even if it were, they are agin it . It is quite true that the applications are difficult, often extremely difficult, but they are also often valid, and if so, nearly always useful.

Secondly, for some reason, the biological mind is seldom attracted to mathematics, or comfortable in a mathematical atmosphere. This may be due to something innate, similar to the well known lack of mechanical ability in poets. I suspect however that it is largely due to the fact that, because of the strong counter-attractions financial and otherwise, of chemistry, physics and engineering, potentially brilliant minds simply do not take an interest in biology. We must do something about this in the future, if progress is to be made. Financial and other returns in the field of biology must be raised to a level with the other sciences or we shall not attract the best minds. If the returns are not naturally as high because of lack of any commercial flavor, then they must be raised by deliberate subsidy. There is also an element of tradition in this matter. During the long period of taxonomy and comparative anatomy, all that was needed was a scalpel and some paper, and it is a little hard now to convince the public and financial bodies that biological research needs large expenditures and large staffs.

Lastly, the mathematical approach to biological problems is undoubtedly one of extreme intellectual difficulty. So much so that an exponent of the art finds it not at all easy to gain enough training in the dual fields of mathematics and biology. We shall have to have help here from professional mathematicians, as well as training our own men. We shall have to try and arrange for a flow of students from the cream of the crop of mathematicians into this field, and to supplement their activites with modern aids to calculation. I think that a full scale electronic computer in Canada, backed up by an adequate staff of bio-mathematicians, and reserved exclusively for biological problems, would yield results of the greatest value. I am afraid though, that the probability of its being set up in the next few years is vanishingly small.

Bio-mathematicians suffer also from lack of background, the science being new. Mathematical physics can draw on an immense reservoir of knowledge and methods, built up by the great physicists and mathematicians of the past, but there have been no Einsteins, Lord Kelvins, Diracs, Heisenbergs or Rutherfords in the short history of bio-mathematics. I am attempting at McGill to start the ball rolling with a small course in bio-mathematics, and I am hoping that I can persuade the mathematicians to turn some of their men loose for thesis work on bio-mathematical problems, of which there are many.

Finally of course, all biological endeavors are intended to be of value to the welfare of Man himself as a species. We shall in the future

have to give much more attention than we do at present to what might be called the "Rearing and Ecology of Man", and a notable part of that biological study will be education itself. Education is not generally thought of as a biological activity, but is is really such in the widest sense, because it is a field of work concerned with the development of Man's most specialised organ, the brain itself.

When a human being is conceived, like all other animals, it goes through a period of embryonic development, during which it acquires its body structure, and expands from a single cell to the billions of cells which constitute the new born infant. This course of development is guided by physiological forces which are by no means understood. We do know that the basic qualities and potentialities, both mental and physical, are determined at least in part by the genes. These are derived from the parents, hence the saying that one of the prerequisites to success is a wise choice of parents. We know also that during embryonic life, the embryo passes through stages reminiscent of the evolutionary history of the species. *Homo sapiens* to which the child belongs.

In each type of animals, the automatic development of the embryo progresses to a certain point, and then ceases, i.e., when the basic form has been laid down fairly completely. After birth, elaboration of structures will occur, but the subsequent development of the higher faculties is *not* automatic, particularly in such a highly developed animal as Man. Rather, such development must be coaxed into being by the endless and arduous process of conditioning which we call "educating and rearing the child". Without this conditioning, the child remains a savage. With it, he becomes a citizen. Unfortunately at present there is some tendency to feel that the development of a citizen as opposed to a mere human being, *is* automatic, and the psychologists who have supported parents in such a belief have much upon their consciences. A child can no more rear and educate itself unaided than a lump of clay can make itself into the Portland Vase.

As I see it, heredity sets the ceilings beyond which, with the most careful and intensive training, the individual cannot progress. Education and environment determine how far towards these ceilings the individual will rise. Because in our times, only very rarely do human beings realise anything like their full potentialities (some of them hardly get off the floor, let alone reach the ceiling), education and environment often seem to play the dominant part in determining what the child will be. Of course, in brilliant and superior children, even poor rearing may not hold them back. In third-rate individuals, the ceilings may be so low that no amount of care can turn such children into useful citizens.

The point I wish to make is this: The adult human beings who will inhabit and manage our world in the next generation will not arise fully fledged by some mysterious process. Citizens do not grow like weeds. They must be reared with care, like orchids. We, the adults of today must fashion the citizens of the future from the children of today, who are the basic clay of humanity ready for the sculptor. Whether our children turn out to be clear-thinking citizens, or merely fools or thugs, rests entirely in our hands, and nowhere else.

Inevitably, with the march of civilization, we shall come to the deliberate training for citizenship in addition to the mere inculcation of facts. We are moving along that line now, and will move much further. The time will come when children will be very carefully screened, and those who show potential ability either as leaders or as brilliant people in any line, will be brought forward ahead of the common mass. Such brilliant

young people should be educated free of all financial worry throughout their lives. For the state to grant a man or woman with an I.Q. of 200 a life-time income of say $20,000 per year would be an extremely good investment.

It is an intriguing thought that if, by a supreme effort, we did succeed in rearing a generation of superior citizens, the process would probably be self perpetuating. Before this can be done however, we must learn that superior citizens are so not because of any law or compulsion, but because of an inner urge, and because the concomitant ideas have become part of their fabric, woven into them in early youth. The looms of such weaving are the home, the school and the church, and not the police force, as is only too commonly thought.

It is also possible that in the future, if for no other reason than that we may be faced with a world wide shortage of food, we may be forced to a degree of regulation in the matter of family life which we would not at present accept. From some points of view of course, we have far too much legislative interference in our private lives by hoards of government officials, and I do not suggest any more of it. What we want is not more regulation, but better regulation. On a strictly objective basis, it does seem peculiar that anyone, regardless of outlook, psychology, ability to rear children, or even desire for children, to say nothing of genetic capacity to produce physically normal children, is quite free to produce them. There are many harmless things which our rulers tell us we may not do, but anyone is quite free to produce criminals who wishes to do so, and at present there is no penalty, though there is coming to be a tendency to feel that the faults of the children spring from the neglect of the parents.

It will not come in your day or mine, or perhaps in the lives of our children, but I can conceive of a far-off utopian civilization in which the state will visit condign punishment on any couple who produce a child without at least some minimal assurance of fitness ti rear it.

We give much thought to education, and spend vast sums on it, but we shall do much more in the future. Teachers, particularly those of children in their young and formative years, are of incalculable importance to the future of our civilization. They should be a mature, very highly trained group, and should be innately suited to their task. Furthermore, they should enjoy an income and social status such that they can approach their delicate and arduous task with tranquil minds.

At present, the teaching profession, particularly as concerns the schools, is at a low ebb. Long years of ridiculously low salaries, and the impact of social restrictions, assisted by the freedom and new horizons of the war, have resulted in a wholesale exodus from the profe sion. Unfortunately, of necessity, the ranks are being refilled at times by the untrained, the unsuited and the merely dull. We shall pay for this yet.

Improvement will undoubtedly cost money, but I can think of some channels down which my taxes are gaily funnelled which appeal to me less than increased expenditures on education.

To conclude then, I think the biological sciences, in their broadest sense are, if not entering, at least approaching an era of expansion, to a state in which they will have an appreciated and understood effect on all phases of our life as citizens of a great and complex civilization. At present, we are cast in the shadow by the phenomenal rise of atomic physics, but the time will yet come when it will be recognised that it is better to put good food into hungry stomachs than to pry energy out of atoms, and that it is better to produce good citizens than radar-operated ash-trays.

REPORT OF THE BOARD OF DIRECTORS AND COUNCIL MEETINGS, 1948

Entomological Society of Ontario

At the invitation of the Montreal Branch on the occasion of their 75th Anniversary, the annual meetings of the Society were held in Montreal, Quebec, on November the 3rd, 4th and 5th.

Meetings of the Board of Directors and of the Council were held in the Lyman Entomological Room, Redpath Museum, McGill University, on the evening of November the 2nd.

At the Directors meeting the Secretary was instructed to prepare a report on the decisions of the Board of Directors and of the Council.

Decisions of the Board of Directors and of the Council

1. *The Canadian Entomologist*

The difficulties encountered by the Editor during his term of office in attempting to bring the publication of the Society's journal up to date were elaborated upon from the editorial viewpoint. Emphasis was placed upon the necessity of frequent personal conferences between the Editor and the printer, on the need of increased technical facilities, and on the sizeable increase in publication costs that would result from transferring the printing of the journal to an Ottawa firm. Several suggestions were offered by members of the Council as means of overcoming the publication lag. Since an increase in cost of publication would entail an increase in the amount of the annual dues and subscription rate to the journal, following a motion by Council the President appointed a committee of three (Messrs. W. A. Ross, A. W. Baker and W. N. Keenan) to confer with the Editor and prepare a definite recommendation to be presented at the business session on Friday morning.

The committee made the following recommendation:

"That it is necessary to transfer the printing of The Canadian Entomologist to a firm in the place in which the Editor resides in order to:

(1) Secure improved technical facilities, and to
(2) Provide for personal consultation of the Editor with the printer.

This should bring about the improvements in The Canadian Entomologist which have been urged at recent meetings of the Society.

Since the projected changes entail increased printing costs, it is recommended that this annual meeting approve an increase in the annual dues to an amount not to exceed $4.00 per annum, effective in 1949, the exact amount to be determined by the Directors on the basis of the increased costs of printing The Canadian Entomologist.

Your committee has considered the matter of the delayed publication of The Canadian Entomologist. It is felt that it is not practical to attempt to bring the journal up to date by the issue of double numbers, as has been attempted. Your committee therefore recommends that:

A double number be produced to complete the volume (LXXIX) for 1947, and that

A double volume (LXXX-LXXXI) for 1948 and 1949 with 12 numbers be produced in 1949, and that

The editor be requested to attempt to make these numbers larger than single numbers produced in recent years."

The recommendations of the committee were adopted in open session at the annual meeting.

The newly elected Board of Directors met at the close of the annual meeting. As a result of the increased costs of publishing the journal which the transfer of the printing to Ottawa would entail, the Directorate decided that the annual dues and the annual subscription rate to the journal be $4.00, commencing with 1949: that student membership dues should remain as at present ($1.00); and that the amount of dues of branch and affiliated Societies be $3.00 per member. The Secretary was instructed to prepare the necessary revions of the constitution and by-laws and submit these to the Provincial Minister of Agriculture for his ratification in accordance with the act under which the Society is incorporated.

Subsequent to the annual meeting it was found that sufficient material was available to bring out a complete volume for 1948 as one issue. The Directors decided to issue this volume in January, 1949 or as soon thereafter as possible, as a commemorative volume of the Seventy-fifth Anniversary of the Montreal Branch. This would bring the journal up to date.

2. The Council instructed the Editor that occasional papers in French be accepted for publication in the Society's journal, but stipulated that an Englilsh summary must be provided with all such papers.

3. *Financial Statement*

The balance on hand, as shown by the financial statement for the year ending October 31, 1948, was approximately $2800.00. This large balance is due to the delayed printing of The Canadian Entomologist, which if published regularly would have accounted for some $1700.-1800. In addition to this, the Society has commitments of some $700.-$800. for reprinting early numbers of the journal, sets of which have been sold on the understanding that the out-of-print numbers would be reprinted and copies of these supplied to the purchasers. The actual balance when present commitments are met will be between $200.-$300.

4. *Annual Meeting Expenses*

Expenses totalling $65.96 incurred by the Montreal Branch, for postage, printing notices of the annual meeting, etc. (exclusive of the excellent programme, the cost of which was borne by the Lyman Foundation), were assumed by the Society.

5. *Membership Cards: Application for Membership Forms*

As there had been many requests for application forms by prospective members, and for membership cards by members, the Directors instructed the Membership Committee to prepare suitable forms for submission to the business session on Friday morning. At this session an application form and a membership card were adopted.

6. *Delegate to the Royal Society*

Dr. E. M. Walker, Toronto, was unanimously elected as the Society delegate to the Royal Society of Canada.

7. *Annual Meeting*, 1949

The Board of Directors and the Council accepted the invitation of the Manitoba Entomological Society to hold the next annual meeting in Winnipeg, in November, 1949, as guests of the Manitoba Society. The Directors and Councillors considered that such a joint meeting was a definite step towards the formation of a national society.

8. *The officers elected and appointed for the year* 1948-49:
President: Dr. G. M. Stirrett, Kingston, Ontario
Vice-President: W. N. Keenan, Ottawa, Ontario
Secretary-Treasurer, Librarian: Prof. R. H. Ozburn, Guelph, Ontario.

Directors
Mr. W. R. Reeks, Fredericton, N.B.
Dr. G. Gauthier, Quebec, P.Q.
Mr. G. A. Moore (President Montreal Branch), Montreal, P.Q.
Dr. G. M. Stirret, Kingston, Ontario
Mr. W. N. Keenan, Ottawa, Ontario
Dr. J. McB. Cameron, Sault Ste. Marie, Ontario
Prof. A. W. Baker, Guelph, Ontario
Dr. B. N. Smallman, Winnipeg, Man.
R. Glendenning (President B.C. Ent. Soc.), Agassiz, B.C.
Councillors
L. S. Hawboldt, Halifax, N.S.
J. B. Maltais, Hemingford, P.Q.
Prof. A. V. Mitchener, Winnipeg, Man.
P. C. Brown, Estevan, Sask.
A. P. Arnason, Saskatoon, Sask.
Jas. Marshall, Penticton, B.C.
Auditors
Prof. L. Caesar, Guelph, Ontario
Prof. H. W. Goble, Guelph, Ontario
Editor: Dr. W. R. Thompson, Ottawa, Ontario
Associate Editor: Dr. A. D .Baker, Ottawa, Ontario

THE INSECT GUIDE by Ralph B. Swaine. .Illustrations by Suzan N. Swaine. 261 pages, 63 plates (48 in colour). Doubleday and Co. Inc., New York. 1948. $3.00.

This volume is a guide to the principal orders and families of insects found in America, north of Mexico. It is well suited to the needs of the general reader.

The introductory portion of the "Guide" explains, with illustrations, the position of insects in the Phylum Arthropoda, and the relationship of insects to plants, animals and man. The basic features of insect structure, growth, and development are also adequately illustrated and discussed.

The main portion of the text gives the more important distinguishing characteristics of 20 orders and 175 families. Some of the general habits of adult and immature forms and the economic importance of the group are included in the discussion under each family. The families are numbered consecutively. The illustrations of representative species of the families are given the same number as the family, thus facilitating ready reference.

The last chapter deals briefly, but adequately, with the more important aspects of collecting, preserving and studying insects. An eight page list of references, useful to the elementary student in entomology, completes the text matter.

This guide with its simple yet orderly arrangement, and its refreshing, life-like illustrations, mainly in colour, should give the lay student an appreciation of the fundamentals of insect classification.

ENTOMOLOGICAL SOCIETY OF ONTARIO

CONSTITUTION AND BY-LAWS

Article I.

NAME

The name of the Association shall be "The Entomological Society of Ontario."

Article II.

HEADQUARTERS

The headquarters of the Society shall be situated at the Ontario Agricultural College.

Article III.

OBJECTS

The Society is instituted to serve as an association of persons interested in the study of the biology and the control of insects, to promote the science of Entomology with special reference to the advancement of the educational, agricultural, horticultural, silvicultural and industrial interests of the Province of Ontario and the Dominion of Canada.

ARTICLE IV

MEMBERSHIP

The membership of the Society shall consist of two groups (1) Members and (2) Honorary Members.

1. Members shall consist of persons paying an annual fee as provided in the by-laws, and whose pursuits or studies are connected with entomology or who are interested in any way in natural history. (R.S.O. 1937 Sec. 8).

2. Honorary Members shall be persons of eminence for their attainments in Entomology and who are elected as such at the Annual Meeting of the Society as provided in the by-laws.

Article V.

OFFICERS

The officers of the Society shall be:—

President
Vice-President
Secretary-Treasurer
Board of Directors
A Council and other officers as provided by by-law

Article VI

ELECTIONS

Directors — The directors of the Society shall be elected by the qualified members at the annual meeting as provided by by-law.

Officers — The directors shall from amongst themselves elect a President and a Vice-President, and shall also from amongst themselves or otherwise elect a Secretary-Treasurer, (R.S.O. 1937, No. 9) and two auditors.

Filling vacant offices — Except as otherwise provided, a vacancy occurring by death or resignation, or failure to qualify as a member, of any officer or director may be filled by the remaining officers of the Society; and it shall be the duty of such officers to nominate and appoint a fit and proper person to fill the office for the unexpired term of the person so dying or resigning; but in the event of the remaining officers being in-

sufficient to form a quorum, or, if for any reason, a quorum cannot be obtained, then persons to fill the vacant offices shall be elected in a manner provided in the next section. (R.S.O. 1937 No. 13).

(1) In the event of an election of any directors of the Society not being held at the time or place directed by by-law, or being for any reason illegal and void, the persons in office at the time when such officers or directors should have been elected shall continue to be the officers of the Society until their successors are legally appointed. (R.S.O. 1937 No. 14, (1)).

(2) In the event of any such none-lection or illegal election a special meeting of the members of the Society shall, as soon as practicable, be called, for the election of such directors; and at such meeting the election of officers shall take place, and the persons elected shall thenceforth, until their successors are appointed, be the officers of the Society. (R.S.O. 1937, No. 14, (2)).

Article VII

DUTIES OF OFFICERS

1. Directors – The Board of Directors in addition to electing specified officers shall have full power to act for and on behalf of the Society in the administration of its finances, subject to the by-laws of the Society. (R.S.O. 1937, No. 10).

2. Treasurer – The treasurer upon his appointment to office shall give such security as the Board of Directors may deem necessary (R.S.O. 1937, No. 16) in addition to other duties as provided by by-law.

3. Secretary – The Secretary shall on or before the first day of September in each year, transmit to the Minister an affidavit, stating the number of members who have paid their dues for the current year, and the total amount of such dues, (R.S.O. 1937, No. 17 (6)), as well as other duties as provided by by-law.

4. Other Officers – The duties of other appointed or elected officers shall be as provided by by-law.

Article VIII

QUORUM

A majority of the Directors shall constitute a quorum except as otherwise provided for. (R.S.O. 1937, No. 9 (2)).

Article IX

MEETINGS

(1) The Society shall hold an annual meeting at such time and place as shall be determined by by-law (R.S.O. 1937 No. 5).

(2) Special meetings of the Society may be called by the president or upon the written request of five members of the Society, provided that one month's notice of the meeting be given, and that its complete agenda be specified. For the transaction of business at such meetings a quorum of Directors must be present.

(3) Regular meetings of the directors shall be held at such time or place as determined by by-law.

(4) Special meetings of the directors of the Society may be called by the president thereof, or, in his absence or on his neglect, by the vice-president, or, in the absence of the vice-president or on neglect of the president and vice-president, by any three members of the Society, of which meeting at least seven days' notice shall be given to each member. (R.S.O. 1937 No. 15).

Article X

OBLIGATIONS UNDER ACT OF INCORPORATION
(R.S.O. 1937)

The Society shall present to the Minister of Agriculture within forty days after the annual meeting – (1) A full annual report of its proceedings which shall include such general information upon matters of special interest to the Society as has been obtained; (2) A statement of receipts and expenditurees for the previous year and of the assets and liabilities duly audited; (3) A list of the members; (4) A list of the officers.

Article XI

BRANCH SOCIETIES

1. Branches of the Society may be formed in any place within the Dominion of Canada on a written application to the Society from at least six members of the Society resident in such district.

2. Each branch shall be required to pay to the parent Society a fee per annum for each paying member on its roll. The amount of such fee to be 75% of the the membership fee as provided by by-law.

3. Each branch shall elect its own officers and enact by-laws for the conduction of its own affairs.

4. Each Branch shall transmit to the parent Society on or before the first of November each year, an annual report of its proceedings.

Article XII

AFFILIATED SOCIETIES

Other entomological societies in Canada may become affiliated with the Society by approval given by the members present at an annual meeting. Members in good standing of such societies become members of the parent society on payment of the fee as for members of branches.

Article XIII

ALTERATION OF THE CONSTITUTION or BY-LAWS

Any change, alteration or repeal of the constitution and by-laws shall be submitted to and approved by the Minister of Agriculture of the Province of Ontario before the same shall have force or effect.

BY-LAWS

By-Law I
(amended December, 1948)

MEMBERSHIP

1. Members shall be of four classes,–

   a. Members as defined under the constitution who apply for enrolment shall pay an annual fee of four dollars ($4.00).

   b. Life members shall be members who pay a single sum as determined by Council and Directors, or its equivalent, to the Society in lieu of annual dues.

   c. Student members shall be any students previous to graduation with a baccalaureate degree, who apply for enrolment and are interested in Biology and who pay an annual fee of one dollar ($1.00). This membership shall be tenable only during the period of active undergraduate study at a recognized educational institution.

d. Associate members shall be non-resident persons who apply for enrolment as associate members, and who have paid the same annual fees as members; such associate members shall be entitled to all privileges of the Society except voting.

2. Honourary Members shall be as defined under the constitution and shall be elected at the annual meeting of the Society on nomination by at least three members. The number of Honourary Members shall not exceed fifteen.

By-Law II

Officers

1. The officers of the Society shall be as designated under the constitution and in addition there may be appointed by the Council an Editor, Associate Editor, Assistant Editor, Advertising Manager and Librarian.

2. The number of elected directors shall be nine, which number shall include one representative from each Branch or affiliated Society.

3. Six councillors shall be elected at the annual meeting, one from the membership resident in one or other of the Maritime Provinces, and one each from Quebec, Manitoba, Saskatchewan, Alberta and British Columbia.

4. The President, Vice-President, elected directors, Ex-Presidents of the Society, Councillors, Secretary-Treasurer, Editor, Associate Editor, Assistant Editor, and Advertising Manager shall consitute a directive body known as the Council.

By-Law III

Term of Office

1. The President and Vice-President shall hold office for two successive years unless in special cases where it may be deemed in the interests of the Society that either or both should hold office for only one year.

2. Officers of the Society other than those elected by the Directors shall be appointed annually by and may hold office at the discretion of the Council.

By-Law IV

Elections

1. Unless otherwise indicated, all elections of the Society shall be decided by a majority vote of the members in good standing present.

2. The nine Directors of the Society shall be elected at the annual meeting, except in a year when the President and Vice-President are continuing in office, when seven Directors shall be so elected.

3. The President, with the consent of the annual meeting, may thereat appoint a nominating committee which shall nominate a slate of Directors and other officers for election.

4. In the election of President and Vice-President, the Board of Directors shall include on their ballot the name of such nominee for each office as the general meeting may, by formal resolution, recommend.

By-Law V

Duties of Officers

1. Council – The Coucil shall be responsible for the general direction of the affairs of the Society and for formulating matters of general policy.

2. President – The President of the Society shall preside at all meetings and, in association with the Secretary-Treasurer, shall execute the details of the affairs of the Society, subject to the general direction and approval of the Council.

3. Vice-President – The Vice-President shall carry out the duties of the President in his absence.

4. Secretary-Treasurer – The Secretary shall have charge of the funds of the Society; he shall receive dues and subscriptions and all monies payable to the Society, he shall make all disbursements for the Society, and shall keep proper records of the finances of the Society, and shall prepare a financial statement of the Society for presentation at the annual meeting.

The Secretary-Treasurer shall keep all other records of the Society and carry on such other business of the Society as may be required. He shall also act as Librarian when no such officer is appointed.

5. Auditors – The duties of the Auditors shall be to properly audit the books of the Society before the annual meeting.

6. Editor – The Editor shall edit the Society's journal, the Canadian Entomologist, in collaboration with the Associate and Assistant Editors.

7. Associate Editor – The Associate Editor shall edit the Annual Report of the Society and collaborate with the Editor.

8. Assistant Editor – The Assistant Editor, under the direction of the Editor and Associate Editor, shall be responsible for special sections of the society's journal.

9. Advertising Manager – The Advertising Manager shall be responsible for the securing of advertisements for The Canadian Entomologist.

By-Law VI

Meetings

1. Annual Meeting – The Annual Meeting of the Society shall be held in November. Unless otherwise decided by the council alternate meetings shall be held at the headquarters of the Society. Other places of meeting shall be decided by the Council.
2. Meetings of Council – A meeting of the Council shall precede, immediately, the Annual Meeting.
3. Directors Meeting – The Directors shall meet before the close of the business sessions of the Annual Meeting for the purpose of electing officers.

By-Law VIII

Publications

1. Canadian Entomologist
   (a) The Canadian Entomologist, a monthly journal, shall be the official journal of the Society.
   (b) Members in good standing shall receive the journal free of charge.
   (c) Non-members of the Society may receive the journal upon payment of a regular subscription fee, payable annually.
2. Annual Report
   (a) The Society shall prepare an Annual Report for publication by the Ontario Department of Agriculture.
   (b) All members and subscribers to The Canadian Entomologist shall receive the Annual Report free of charge.

CAN ECONOMIC ENTOMOLOGY BE AN EXACT SCIENCE?

DR. W. R. THOMPSON,
Commonwealth Bureau of Biological Control, Ottawa, Ont.

Whether Economic Entomology can be an exact science is, I think, a question in which we should all be interested. I propose therefore to examine it with the care that it deserves though I will try to make the discussion as brief as possible.

Broadlly speaking, the sciences can be divided into two classes: the *speculative sciences,* whose object is simply the *discovery of truth*: new facts or new laws; and the *practical sciences,* whose objest is the *production of facts*: causing something new to happen.

It is clear that Economic entomology is a practical science . Practical sciences are more properly called *arts.* Medicine and engineering as well as economic entomology are really arts. They concern themselves with strictly individual sequences of events which, precisely because they are individual. do not come under any really general laws: for example the course of a disease in a particular patient, the development of an infestation in a particular field.

When economic entomology is strictly defined, therefore, it must be recognized as an art and cannot be an exact science.

But all arts utilize science in the strict sense and what we want to consider is the collection of facts or laws or principles belonging to entomology in general but specially utilised by economic men; and we are asking, whether these can constitute an exact science in the really rigorous sense of the term?

The first point to consider is what we mean by the words: *exact science?*

The word *science,* in the modern world, usually refers to such investigations as physics, botany, zoology, dealing with the things of the material world by observation and experiment. But if we think of such subjects as algebra and geometry, we realize that our first. definition has narrowed down the meaning of the word science too much. It is better and simpler to say that *science* is *knowledge.* Basically, we have a scientific knowledge about something when we *truly know* what it is.

The word *exact* involves greater difficulties. It obviously means something more than *true.* If we say that a certain spray will kill *some* codling moth larvae in an orchard, that may be a *true* statement but it isn't an *exact* statement. To have that we must be able to say *how many*: we must give our prediction a *numerical value.* In other words, an *exact* science states its results in quantitative terms.

We are trying to probe a little farther than we usually do into our subject. We have to keep on asking questions so long as there is a chance that we can get answers! The next question, which is very simple and yet very difficult is: *what is quantity?*

Since the time of Descartes there has been a rather strong tendency among scientific men to say that *quantity is the same thing as matter.* Descartes thought and many subsequently agreed, that the qualitative attributes of things are illusory, not inherent in them but put in by us. This view greatly simplifies the task of science; but it really will not bear a critical examination. Suppose we admit – as many currently do – that the green of a rose-leaf or the red of a rose are merely subjective sensations, yet there must be some intrinsic qualitative difference at the origin of the two different sensations. No matter how we argue we have to admit that the rose leaf and the rose petal *differ in kind.* We could not formulate a recognizable description of a butterfly wing, for example – unless there were qualitative differences in its various parts. Material things must therefore be more than mere extension as Descartes suggested. They are not pure quantity. Quantity is, therefore, not the same thing as matter.

It is evident that primary realities, like substance, quality, quantity etc., are very difficult to define. Aristotle says in the Metaphysics that quantity is "that which can be divided into parts of *which each can exist by itself*". Perhaps this is a little obscure. What Aristotle means, I think, is that quantity is that which makes it possible, in something which is qualitative one, to have *parts outside parts*. Take a white sheet of paper. Considered as white, it is *one;* there is *no* distinction between one part and another. Strictly speaking in this respect it has *no* parts. It has parts simply in so far as it is extended in space. The parts we can designate in this extension are qualitatively *identical* but they differ because one part is *outside* the other parts.*

Our knowledge of quantity depends essentially on the *enumeration of its parts.* This is really all we can know about it. How we number the parts depends on their nature. If they are *separate* or *discrete,* like the members of the association in this room we have only to number them in the ordinary sense: i.e. to count them. If they are *not separate,* as in the case of a sheet of paper or a bowl of water, we must *divide* them up into separate parts of which we take one, arbitrarily as a *minimum standard* and enumerate the parts of the whole as multiplies of this *minimum mensura.*

Quantities as such, can be added or subtracted. We cannot do this with qualities. If we add blue to red, we get purple, which is a quality different from either and is not a multiple of either. We cannot properly speak of a number of colors, if the colors are all different. Such a collectivity is properly called a *multitude, not a number.* Furthermore we cannot enumerate the members of a series of different colours in relation to any one of them, taken as a minimum standard. Every one is intrinsically *different* from the others. As you know, we can only deal with colours *as colours,* by means of a chart on which colour is individually given and designate the colour of our specimens by comparison with the chart.

But any attempt to constitute a whole science on this basis is bound to break down because it has to deal with irreducible multiplicities and efforts to achieve precision merely make things worse by increasing the number of components. This seems to be the reason why the observational sciences of the middle ages failed to make progress. The object of science is to reduce the *apparent multiplicity* of things to *unity.* The simplest way to do this, in the case of material objects, is to consider them as *quantities,* which permits them to be expressed as multiples of a unit of measurement—of some particular quantity, taken as a standard. When this is done we have an *exact science.* The data of an exact science are expressed as multiples of a standard unit of measurement, universally accepted. When there are regular sequences or relations between the quantitative values noted, we have quantitative laws. Exact sciences formulate the laws they discover in quantitative form. In other words they are necessarily mathematical.

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*It may be objected that this definition includes that which it is supposed to define or does not define its object in terms of elements independently known. There is some truth in this because "outsideness" has not been defined. We could say that quantity is what permits the existence of distinct units of the same kind; but if we are asked in what their distnctness consists we can only reply that one is *outside* the other. The other. The difficulty is that "*outsideness*" is primarily the object not of intellectual but of sensory perception and cannot therefore be reduced to terms from which sensory knowledge as such has been completely eliminated. "*Outsideness*" is in fact, a sensory irreducible.

Thus, to become an exact science, entomology must state its results and formulate its laws in quantitative form. Is this possible and if so, how; and what are the limitations of the methods that must be adapted to attain the desired result?

Taking the word *science* in the sense of knowledge, we may note that sciences fall into three great groups, distinguished by the nature of their objects.

In the first group we have the sciences whose object can neither exist without matter nor be conceived without matter. This group includes the descriptive and experimental sciences, dealing directly with concrete material objects: descriptive physics, chemistry, geology, botany, zoology and the like. When we say that the objects of these sciences cannot *exist* without matter we are speaking as *realists*: we are saying that every *real* insect, for example, is a *material* insect, existing outside the mind. We cannot even think of an insect as non-material; but this idea itself includes the nation of materiality. This is what is meant by saying that the insect cannot be conceived without matter.

The second group of sciences are those whose object cannot exist without matter bat can be conceived without matter. These are the mathematical sciences. The characterization just given does not involve any great difficulties. Obviously we cannot have a pure number such as 2 or 10 – I am talking of course about the number, not about the symbol of the number – existing as such in the real world; we can only have a number of things – 2 apples or 10 men. Similarly, we can't have a pure Euclidean line – length without breadth or thickness or a pure circle: we can only have linear or circular things. But as objects of mathematics these are conceived strictly without matter. We can *think* of a *myriagon* – a plane figure with a thousand sides – and this concept is quite clear and intelligible. But we cannot imagine it, tnough a thousand-sided thing could exist. Thus the concept is strictly non-material and does not even include the materiality implied by the image.

The third group of sciences comprises those whose object can both exist without matter and be conceived without matter. Such a science is metaphysics. The discussion of these subjects would take us too far from our argument and I mention it merely to complete the series.

We have defined the various groups of sciences in function of their objects. We have now to consider how these objects are attained by the scientist: i.e. how the structure of these sciences is built up.

I think that the best method is perhaps to begin with the sciences of the second group: the sciences of quantity, generally known as mathematics; because before we consider whether entomology can achieve the same status, we want to learn exactly what that status is.

The all-important thing about these sciences is that they are *deductive sciences.* Observation and experiment, in the sense of discovering what something *is doing* in nature or in the laboratory, aren't necessary, because the objects of mathematics dont *do* anything, at least, not as objects of mathematics – as pure mathematical entities. All the scientist has to do is to *contemplate* the entity to be studied and reason correctly from the knowledge he has to the knowledge to be acquired.

Thus, if he starts with the definition of a Euclidean triangle as a closed plane figure with three straight sides, he can discover by pure reasoning about this definition, which tells us what the triangle is or what its *essence is,* all that it is possible to know about the triangle.

Between the nature of the triangle, as made known to us by the initial definition and the truths we find out about it there is a *necessary* connection. When we understand the reasoning involved, we *see* that the three interior angles of a Euclidean triangle *must* be equal to 2 right angles and cannot be otherwise. Thus, between the triangle as initially known to us and the information we later acquire, there is a relation through reason alone – which reason alone can follow through.

Some modern authors like Lancelot Hogben have spread confusion over this subject by affirming that the propositions of mathematics must be established by measurement and apart from this, have no intrinsic necessity. Hogben gives, in his "Mathematics for the Million", a figure of a vessel so constructed that when you pour two pints of water into it, one runs out. This proves, according to Hogben that 1 plus 1 doesn't necessarilly equal 2. The truth is, that 1 plus 1 and 2 *are the same.* They differ only *by our point of view.* Moreover, owing to the impossibility of making an absolute measuring apparatus, completely exempt from error, it is impossible to prove, by empirical means, the proposition that 1 volume added to another volume makes exactly 2 volumes. The figures and instruments used in mathematics – in geometry, for example, – are merely *aids to* mathematical reasoning. They do not duplicate it.

It is important to notice also that in mathematics we can establish an absolutely general proposition. For example, the proposition that the 3 interior angles are equal to 2 right angles is true of *all* plane Euclidean triangles: in other words of *the* triangle. *The* triangle is an abstraction and it is with abstraction that mathematics deals.

Now the first group of sciences, to which entomology belongs, deal, not with abstractions but with realities, taken in their individual concreteness to begin with and they build themselves up by *induction,* not by *deduction.* Thus entomology begins with the concrete individual insect. By observation and experiment it determines its morphological characteristics and finds out what it does. From repeated observations of this kind, it constructs a definition, applicable to all the individuals of the same species. This definition refers, of course, to an *abstraction* but we must admit that the abstraction is realized in all the individuals of the species, otherwise the species is a pure figment and there is no basis in nature for the specific definition. Experience does not agree with this idea. Thus the specific definition, which we attain by induction (which is a passage from the particular to the general) must have a general validity; and signify more than the attributes of one concrete individual as perceptible to the senses.

Nevertheless, the contemplation of this definition will not make it possible for us to proceed from it by the mere exercise of our reasoning powers, to attributes not comprised in it, as we proceed from the definition of the right-angled triangle to the truth that the square on its hypotenuse is equal to the sum of the squares on the other two sides. It is certain that if we had never seen a flying animal, we could not certainly say that wings permit an animal to fly. Even after we knew this, we would never have known that the parasite *Prestwichia aquatica* uses its wings to swim if Lubbock had not actually observed this. As we multiply observations and experiments we feel more and more certain that certain correlations of structure and function have a general validity. Our curve of data *tends* to the point where it can become the basis of a real deduction; but this point is only attainable, as the mathematicians say, in the *limit,* which really means *never.* Thus sciences like entomology are *irremediably inductive.*

But the question is, whether this is incompatible with the status of an exact science? In sciences like entomology and particularly economic entomology, the tendency to concentrate on quantitative data – on the *Mensurable* – has steadily increased. In systematic entomology, for example, the rough linear measurements of individual specimens has in many cases been replaced by measurements of the most important parts of a series of specimens and in some cases the well-known frequency curves are used to differentiate closely allied species or races. The population values which it is the task of economic entomologists to alter, are now almost always expressed in definite numbers and related to quantitative units of the environment on the one hand and of the materials used in treatments, on the other. Finally, the aplication of statistical methods is generally considered, I think, to increase to a very considerable degree the accuracy of the data presented. These facts seem to suggest that economic entomology is well on its way to becoming an exact science and that it can eventually expect to reach this goal.

Entomologists addicted to mathematical speculations are sometimes inclined to say that the visible necessity that relates antecedents and consequents in mathematics actually does exist in the facts and processes with which entomology deals, in common with the other natural sciences. I will freely admit that I rather believed this myself at one time. A rather common fallacy of this type encountered in papers on biological control is that the relation between host and parasite populations necessarily implies *oscillations.*

In the first place, the word "oscillations" is not sufficiently well defined. It *might* refer to the continuous movement we get in a pendulum. In this case it refers to the alteration in the numerical value of insect populations in a series of generations. These are plotted in a continuous curve but the succession of the values in nature is actually discontinuous.

Now it is possible to write equations signifying a relation between host and parasite populations which, when numerically translated, give population figures forming points on one or more curves of the oscillatory type. Equations developed in the infinitesimal calculus gives us, theoretically, population values forming a continuous series: you will remember that Newton called this the method of *fluxions.* Actually there is a fundamental fallacy here, but I won't dwell on it, as it makes no difference to the present argument. The point I wish to make is quite simple. If we write an equation signifying host parasite relationship, of a certain form, then what can be broadly called oscillation necessarily follows. But we can easily write the equation in such a way that oscillation does not follow. In either case the relation between equation, considered as a cause or antecedent and the "oscillation", considered as an effect or consquent, has nothing whatever to do with the relation between real events in nature. The case is exactly like that of the triangle. The relationship is not real, but ideal and it is not due to the action of real causes acting in the real world but merely to ideal or logical connections which exert their effect only in the mind.

In the real world a multitude of real causes act on populations in every generation and by the ensemble of these causes the population values are determined. It is therefore clear that if there is an oscillation it is impossible to abstract from the real causes extrinsic to the host – parasite relationship. This relationship does not exist *in abstracto* and therefore what it implies *in abstracto* does not necessarily occur in reality.

Thus, even though we restrict ourselves to quantitative elements, we cannot make an exact science out of economic entomology, simply by trans-

posing it into mathematical form. This simply transforms it into something unreal.

There is, however, a method of attaching sciences like entomology of the factual or inductive type, to the deductive science of mathematics in such a way as to make them participate to some extent, so to speak, in the prerogatives of mathematics. This method, it may be said was well known to the philosophers of the middle ages in the examples of theory of music and astronomy which they termed sciences materially physical and formally mathematical; but it did not really begin to develop until the Renaissance.

We are all familiar with this method though we don't always distinguish it clearly, as we should, from the mere transposition into mathematics.. Thus, suppose we weigh a growing caterpillar in the successive stages at equal time-intervals and plot the measurements on a graph. We shall then obtain a geometrical figure. In such cases it is sometimes possible to find a mathematical formula which corresponds to a curve passing through the same points. This formula can then be regarded as the mathematical law of growth in weight, for the caterpillar concerned. In the same way we can take some organic form such as an Echinoderm egg or the thickening on an insect trachea, or the border of a snail shell and see, by a comparison of real and theoretical measurements, whether it corresponds to such geometrical forms as the sphere. the helicoid or the logarithmic spiral. This treatment of biological data is exactly comparable with what we call *mathematical physics.* The success of this department of science suggests that by following the same method entomology may succeed in transforming itself into an exact science. Since the laws discovered are mathematical, such a science, it seems, can be deductive. For example we could deduce from the mathematical law of weight increase, what the weight was at a moment when we did not actually measure it.

It would appear furthermore, that the application of statistical methods to our counts and measurements should enable us to eliminate the errors due to our instruments and operative procedures and thus give our resultls the real accuracy implied by the term: exact science.

There is no doubt that statistical analysis is necessary and perhaps indispensable in economic entomology; but perhaps its true significance is not always appreciated.

Suppose we wish to make an accurate quantitative determination of some morphological character such as the length of the antenna of a Hymenopterous parasite, or the number of rays in the dorsal fin of a fish. To get the data we want, we are not satisfied to deal with a single specimen though we can do so with very precise and delicate methods. We examine a large number of individuals and tabulate the results we get. From a great mass of studies of this type carried out on material of all kinds, a very definite result has emerged, to which we are now so accustomed that we expect it as a matter of course. The data collected from a large number of specimens can be arranged in a frequency curve, which in one of its simplest expressions corresponds to the curve of the coefficients of the terms of the expansion of the binomial (a plus b)^n.

Suppose that the curve of data follows the mathematical law exactly. Even in that case it should be carefully noted that it does not and cannot give us the exact quantitative value, for the species considered, of the characteristic we are trying to measure. In fact, what the frequency curve really proves is that for the characteristic considered, *there is no exact quantitative* value. The curve tells us the probability p that any particular specimen will have a particular quantitative value; for example, the *chance* that

the dorsal fin of an individual fish will contain 10, 15 or 23 rays; or that the antenna of a hymenopterous parasite will be 1 or 1.5 or .75mm. long. The kind of result we get is that there is 1 chance in 8 that the antennae will be 1.5 mm. long. In other words, statistical methods do not enable us to give exact and definite quantitative values to the attributes of material objects; what they do, is to show us that these valules are not in themselves exact and definite; or as some put it, they are *not absolutely determinate.*

As everyone knows, the experimental physicists have come up against the same difficulty, though they were dealing with entities of the utmost simplicity, handled under experimental conditions of a rigorous precision unattainable in a science like entomology. It will be remembered that the physicists found it impossible to determine the speed *and* position of an elementary particle at a particular instant. Some of them say that this difficulty is in the nature of things. Curiously enough, Aristotle would have agreed with them, in the most profound sense. His answer to the celebrated paradoxes of Zeno the Eleatic depends on the principle that if a particle is moving from A to B it has no doubt a certain speed yet it cannot be said at any moment of the flight to *be* at any place. It *could* be *there* if it stopped but as it does not stop it never *is* in any definite place, it is merely *going through it.* This is really implied by the idea that the movement is *continuous.*

Thus there is a certain basic indetermination in the events of the material world in the sense that we cannot clearly understand the relation between antecedents and consequents and see the effect as rationally required by the cause. Even a simple thing like the boiling point of water was not *deduced* from the known properties of water. It was *discovered* by experiment. We may find that a certain process follows a mathematical law, with approximate accuracy. But it must be realised that the mathematical law does not *govern* the process it merely expresses it. If it really *governed* it, natural science would be a purely logical construction and could be deduced from a few fundamental axioms, like geometry, as certain idealist philosophers like Descartes and Hegel believed.

Two difficulties must be carefully distinguished here. The first is the enormous multiplicity of factors involved in the genesis of biological events. After this reaches a certain point, the mathematics approrpriate to the case becomes practically impossible to handle. However, Tyndall, who considered *only* this difficulty, thought that a superintelligence, contemplating the original nebulal could predict the battle of Waterloo or some other real event in history.

But when the second difficulty is realised it becomes evident that this would never be possible. Material things that exist in the real world are not, at any given moment, all that they can be. They are *really* changeable and the results of their changes are not things that are there to be seen, if we only look hard enough. They are not visible in any sense until they come into existence. Thus the tremendous multiplicity of factors acting in the real world has not merely the complexity of an elaborate mathematical equation, which is theoretically but not practically manageable; but implies a genuine unpredictability because the actual combination of factors has never been observed to operate and until it has, we cannot really be *sure* what its effect will be. Much less can we *see* this effect in its causes.

It is therefore clear that entomology and, *a fortiori,* economic entomology can never range itself among the exact sciences. It is a mistake to imagine that by any mathematical subterfuges, we can dispense with the direct contact with nature. Observation and experiment must remain the basic elements of entomological science.

THE LIGHT REACTIONS OF THE SPRUCE BUDWORM, *CHORISTONEURA FUMIFERANA* CLEMENS (LEPIDOPTERA* TORTRICIDAE)

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(1) INTRODUCTION

This paper deals with the orientation reactions exhibited by larvae and adults of the spruce budworm, *Choristoneura fumiferana* (Clemens), (12) in response to stimulation by light. The insect is an important pest of the coniferous trees, *Abies balsamea* Mill, and *Picea spp.*, which comprise the pulpwood stands of the forests of northeastern North America. Hence, at present, it is the subject of many investigations. The work reported here is part of an investigation designed to provide data for the development of studies of the effects of weather and climate upon the spruce budworm.

(2) EXPERIMENTAL MATERIAL

Unless otherwise noted, the larvae used in the following experiments were collected from an area of heavy infestation near Lake Nipigon, Ontario, during October, 1945. Branches infested with overwintering larvae were stored first under snow cover in a screened insectary near Sault Ste. Marie and, later, before the spring thaw in March, 1946, were transferred to a cold room held between 2.5° and 4.5°C. Bundles of foliage were brought from could storage as required, and emerging larvae were collected with a brush or a pump-driven aspirator and reared on balsam foliage at 20-21°C. until the required instars were obtained.

In order to study the reactions of adults to light, sixth instar larvae and pupae were obtained in June, 1947, from the Ontario forest districts of Sault Ste. Marie, Gogama, North Bay, Geraldton, and Kenora. This material and all emerged adults were held at 20-21° C. until required for use in experiments.

(3) APPARATUS AND GENERAL PROCEDURE

During preliminary observations, one-and two-light techniques were employed as a matter of routine, since variations of these methods have been used by many others in studying the light reactions of a variety of organisms (*vide* Fraenkel and Gunn (11) for lists of references). Special techniques and additional equipment employed were varied to suit the needs of particular experiments as the work progressed. Consequently, they will be indicated concurrently with the descriptions and results of these experiments. Thus, the description that follows is concerned with generalities applicable to much or all of the work.

Most of the work was done in a windowless rearing room held at temperatures between 20 and 21°C. The majority of the observations in this room were made with the aid of one or two lights mounted on a two-light board made of a square metre of black "Masonite." The isoceles right-angled triangle constructed on this board had a hypotenuse 72.5 cm. in length. The light sockets were mounted at the ends of this line. The bisector of the right angle, termed the 0° orientation angle in some two-light experiments, was 38.8 cm. in length, this distance being measured from the apex of the angle to the centre point of the hypotenuse. In the majority of both one-and two-light experiments, larvae

* Contribution No. 2551 from the Division of Entomology, Science Service.

were released at the apex of the right angle. Except when otherwise stated, the lights used with the board were 25-watt frosted lamps giving a 1:1 intensity ratio at the apex of the right angle.

The best photometric equipment available consisted of matched Weston "Photronic" cells used in conjunction with a milliameter. This equipment had been designed for use only as a null-point indicator. Consequently, intensities in the following work are reported as ratios rather than in any of the usual photometric units, because no standard lamps were available to check the original conversion curves given with the cells.

(4) LARVAL REACTIONS

(a) *Responses to a discrete source*

(i) Instar Similarities and Differences

The need for an analysis of the light reactions of larval budworms appeared as a subsidiary problem during the course of a study of the behaviour of larvae in gradients of temperature and evaporation. Like many species of caterpillars, spruce budworm larvae at first appeared to be so consistently positive to directed or diffuse light over wide ranges of temperature and evaporation that this response was utilized as one routine method in the primary investigation, which will be discussed elsewhere. Hence, when anomalous behaviour at room temperature was noted, it was necessary to study this further in order to check the validity of conclusions drawn from data obtained in the gradients. More intensive observations of the responses to light gave instar similarities and differences described below.

Successive two-light tests of 100 freshly collected larvae of each of the six instars were made at the room temperatures noted, and the results were grouped by trial number in frequency distributions having class-mark intervals each amounting to a 5° angle of orientation. Ten minutes were required to complete a trial for a group.

During the first trial, all the larvae of each instar responded positively to light, moving towards but between the two lights. Inspection of the distributions obtained showed no orientation differences among the six instars. In each case, the greatest number of individuals of any instar travelled directly between the two lights, crossing the line joining the lights near its centre, and thus placing the peak of the distribution in the orientation angle class of 0°. Noticeable secondary peaks were lacking. In short, the distributions were typical of the results to be expected in the usual experiments of this general type.

Subsequent trials with the same groups of larvae revealed inter-instar differences in the types of distributions obtained. The first two instars, in their twentieth trials three hours after the initial trials, gave distributions which did not differ significantly from the originals. This relative rigidity of behaviour was characteristic of the first two stages at all times, and, under certain conditions, was followed by the third stage.

Changes in behaviour took place in later trials of the fourth and subsequent instars, but were not immediately recognizable as such, because the use of groups masked behaviour of individual larvae. Nevertheless, anomalous distributions were obtained, which were not at all repeatable. Secondary peaks sometimes occurred, and, often, many larvae would not move towards the lights at all, but moved away from them instead. It was soon recognized that these phenomena were not solely the results of normal variability but, instead, were produced by the occurrence of different types of behaviour masked by the group method employed. Consequently, this method was abandoned temporarily and individual larvae were studied with single and twin lights.

Using one light, it was found once more that larvae of the first two instars maintained a relatively rigid positive orientation, giving no reliable evidence

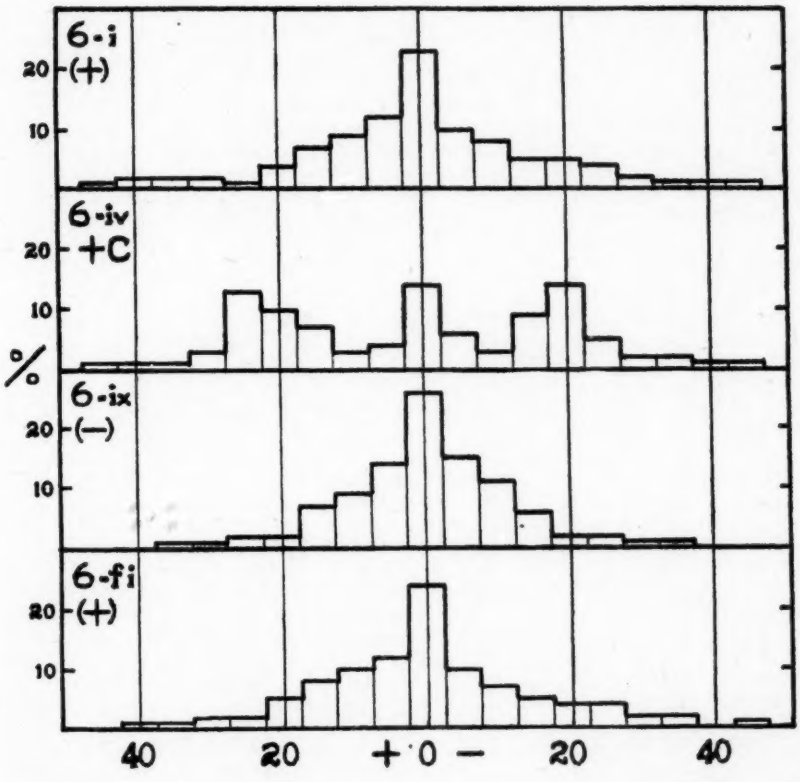

Figure 1. Intra-instar differences in orientation to two lights which appear in later instars, as illustrated by instar 6. Trial 1.: photopositive larvae; trial 4: photopositive and compassing larvae; trial 9: photonegative larvae; trial f-1: larvae returned to photopositive orientation overnight. Ordinate: percentage frequency; abscissa: orientation angle, degrees.

of compassing tracks *cf.* v. Buddenbrock (5) and Fraenkel (10). The third instar also showed no tendency towards compassing* behaviour, but, after 10 to 50 trips to the light, it became, to all outward appearances, indifferent to the light. Larvae wandered about the board, following devious paths which showed no apparent relation to the positions or intensity of the light. The paths were of the twisted and convoluted type usually considered to be followed when an organism is disorientated (v. Buddenbrock (4)).

When fourth and subsequent instars were tested with one light, the majority of individual larvae tested directly after they were removed from the feeding jars reacted photopositively, just as the groups had reacted. However, on the first trial, a few struck a course at an angle to the light, and some went directly away from it. Judging by the comparative widths of the body and head capsule, each of these larvae was at least a half-grown larva in its particular instar. Extension of the area of the board showed that larvae moving at an angle to the light were compassing by it, while those moving away from it were behaving photonegatively. This behaviour was checked with 50 larvae of each instar and was found, with certain qualifications, to be repeatable. (Additional numbers were used in later experiments, which confirmed the results obtained with the groups of 50.)

Additional trials showed that individuals which were originally positive finally began to compass after an extremely variable number of trips directly to the light. Such larvae occasionally reverted to ordinary photopositive behaviour for one or two trips, the straight paths then obtained being easily distinguished from typically spiral compass tracks. Finally, it was found that compassing larvae, again after a variable number of trips, suddenly began to behave photonegatively. This transition was abrupt, and, for the duration of the time on the board, final, since no photonegative larva was ever observed to revert to compassing or photopositive behaviour while left to its own devices on the board.

Both the compassing tracks and the photonegative tracks obtained fell into well-defined patterns. Thus, they cannot be considered to indicate indifference to the source of light such as was postulated for the third instar. All stages of development within the third instar eventually became indifferent to light. Similarly, all stages within any of the last three instars became photonegative. However, it was noticed that well - grown larvae in any of the last four instars produced the anomalous behaviour patterns either on the first trial or by the twentieth trial at the most, whereas the small, young larvae in each instar on occasion could be tested 30 to 50 times before giving any indication of the anomalies. Thus, besides recognizing inter-instar differences in behaviour, it was also necessary to allow for intra-instar differences based on the amount of development within an instar.

The separation of three different types of photic orientation common to the last three instars provided a means for correctly interpreting the secondary peaks and other anomalies which had been noted in the groups of larvae tested with two lights. These may now be illustrated with particular reference to the sixth instar, which exhibited well - defined differences.

Figure 1 shows the distributions obtained for several trials of a group of sixth stage larvae. In the first trial, the larvae were photopositive. In the fourth trial, secondary peaks arose when a number of larvae compassed by one or other of the two lights, while the remainder of the larvae remained photopositive. The figure shows that these secondary peaks lie in the zones through which larvae compassing at constant angles of 30 to 40° passed in the course of their movements. These larvae compassed by one or other of the two lights, and

* The term "compassing" is an abbreviation of "light-compass-movement". It refers to displacements in which a source of light is definitely used as a reference point though the animal may not travel in line with it.

did not strike a resultant course between them. This is not typical behaviour for caterpillars, and the point will be examined further in the discussion of the results.

In the ninth trial, as indicated by the minus sign at the side of the diagram in Figure 1, all the larvae were photonegative, moving away from the lights, but once more moving with reference to the positions of both lights, as they did when they were strictly photopositive. Thus, they again exhibited a typically-balanced distribution. The ends of the distribution halted at orientation angles lower than 45°, with a resulting slight increase of larvae in the central region. This is a result of the difference in efficiency between positive and negative orientations to light, because of the location of the stemmata.

The last illustrated trial of the series, designated f-1 in Figure 1, shows the results of a test made 12 hours later, after the larvae had been placed in a feeding jar overnight. This test showed that the larvae once more responded *positively* on their first trial on the board, the distribution obtained comparing favourably with that shown in diagram (i).

This last point was checked with individual larvae of the last three instars, and it was definitely established that photonegative larvae which would not reverse their orientation while on the board, behaved photopositively when tested after an extended rest period in the feeding jars. During the next set of tests, the transition from positive to negative began again. The same sort of occurrence was found to hold true for instar three in its disorientated phase. Although sensory adaptation might have been postulated to close the problem at this point, it was noted that larvae stored in empty jars did not revert overnight to the original photopositive state, but retained the anomalous behaviour patterns. This suggested a food factor.

(ii) The Effects of Starvation

Experiments were devised to assess the importance of starvation in the process of photic reversal. However, it was first necesssary to check the possibility of sensory adaptation, although this hypothesis was suspect on the grounds that larvae which had never been tested before might exhibit the anomalous behaviour during their first trials on the board.

Three lots of 50 sixth-stage larvae were collected from the array of feeding jars. Each individual was tested with one light before being passed to the next stage of the experiment. The results of the first trial are shown in Table 1.

Table 1 Original photic orientations of sixth-stage spruce budworm larvae tested before being starved.

Type of Orientation:	Group number:		
	1.	2.	3.
Photopositive	45	47	47
Compassing	2	2	1
Photonegative	3	1	2

Group 1 was then tested as a group with two lights, with successive trials for a period of four hours. Group 2 was stored in an empty jar in diffuse light, and Group 3 was stored in an empty jar in complete darkness. At the end of the four hours, the individuals of each group once more were tested with a single light. The results of the final trials are shown in Table 2.

Table 2: Final photic orientations of sixth - stage spruce budworm larvae tested after being starved for four hours in directed and diffuse light and in darkness.

Type of Orientation:	Group number:		
	1.	2.	3.
Photopositive	0	0	0
Compassing	3	1	2
Photonegative	47	49	48

Photopositive behaviour with respect to a discreet source disappeared in all groups, whether they had been exposed to conditions of continuous movement and orientation to a source of light, to a diffuse source of light in confined quarters, or to complete darkness. When another 100 larvae which responded photopositively were stored in darkness in an empty jar for two hours, 50 of them reacted photonegatively on release, 30 compassed and 20 remained photopositive. The photopositive larvae were all young larvae, whereas the others of the instar were half - grown or fully-grown.

These tests eliminated the possibility of adaptation to a light source from the mechanism of the reversal of orientation, and indicated the importance of time, rather than the number of trials involved. Recognition of the presence of the time element lent weight to the hypothesis that progressive starvation might be involved in the primary reversal from positive to negative, and that feeding could bring a return to the original state.

Large larvae of any of the last three stages which reacted photonegatively the first time they were removed from a feeding jar had a slightly flaccid appearance. Photopositive larvae of the later stages always appeared and felt firmer than the photonegative larvae. General experience in the rearing work had shown that the mere presence of a larva on foliage did not imply that it was feeding actively. These facts were related to the problem at hand. The sixth stage was chosen for testing because it exhibited more definite changes in appearance than did earlier instars.

Two feeding jars were each filled with 50 larvae, which were allowed to feed undisturbed for 24 hours. At the end of this time, all the larvae in the first jar reacted positively, while two in the second jar were photonegative. Larvae of Group 1 were disturbed by prodding every half hour for six hours. Care was taken to see that individual larvae were driven from their nests in the shoots each time the contents of the jar were disturbed. At the end of the period, 30 larvae were on the sides of the jar, and the 20 on the foliage were moving about instead of resting in one spot. The second group was left unmolested for the same length of time. At the end of the period, the majority of the larvae in the second group were much firmer than those in Group 1. When all individuals were tested once with one light, the results appearing in Table 3 were obtained. These results indicated still more clearly that some effect of starvation was involved in the process of reversal of orientation from positive to negative. The six larvae in Group 1 which remained positive were all young larvae, judging by the relatively small sizes of their bodies in relation to head capsule sizes.

Table 3. Comparison of final photic orientations of spruce budworm larvae disturbed and undisturbed while feeding over a six-hour period.

Type of Orientation:	Group number: 1. (Disturbed)	2. (Undisturbed)
Photopositive	6	46
Compassing	14	2
Photonegative	30	2

At the suggestion of Dr. J. M. Cameron, some of the flaccid, photonegative larvae were inflated to a normally or abnormally turgid appearance by the injection of Ringer's solution into the digestive tract through the anus. Sixth stage larvae had to be used in this and following injection experiments, because smaller ones were too easily injured. Larvae used in the various injection experiments were not previously anaesthetized, since this made them too sluggish for too long a time after external application of sufficient anaesthetic to quiet

them. Larvae uninjured by the hypodermic itself showed no ill effects from any injection, and pupated normally.

Before passing on to a description of the experiments, it should be mentioned that in some of these (as in the first noted immediately above and below) it was necessary to select larvae which were initially photonegative In the search for photonegative larvae for these experiments, 30 sixth stage larvae were found which never became photonegative, but, at the most, became indifferent to light as did the third instar.

In the first experiment, 56 larvae of each sex were injected anally with 0.01-0.02 cc. of Ringer's, the dosage being controlled by the size of the larvae. Previous to the injections, males orientated as 40 negative and 16 compassing, while females orientated as 43 negative and 13 compassing. Some larvae moved so that part of the injection was lost, and, in attempts to re-inject these, 4 males and 2 females were injured. All the remaining males (52) became positive, while 52 of the females also became positive and the two remaining switched from photonegative behaviour to compassing behaviour, a reversal which never occurred without manipulation.

In another test with an additional 40 larvae of each sex, in which males initially orientated 36N and 4C, while females orientated 35N and 5C, injections were done through the prothoracic segment backward into the digestive tract. All the males became positive, three females were injured, but two of these managed to compass, while the remaining 37 became positive.

These results involved the degree of distension of the digestive tract in the mechanism controlling photic orientation, but did not eliminate the possibility that water loss might have been involved, the loss being replenished by the injected aqueous solution. Therefore, on the assumption that a mechanical pressure change brought about by the swelling or shrinking of the tract should be equally effective whether it was brought about from the inside or the outside of the animal, a number of photonegative larvae were ligatured around different body segments. (In the following description, the prothoracic segment is designated segment I.)

Totals of 166 larvae of each sex ligatured with cotton thread and compared to equivalent numbers of controls showed that ligaturing on segments I-III and VII-XIII produced no changes in behaviour. Two individuals in each of the segment IV and VI groups compassed, but closer inspection revealed that the threads angled across segment V (the second abdominal segment) in each case. When this error was corrected, all the larvae returned to negative orientation.

Totals of 50 larvae of each sex were ligatured around the fifth segment. One male and 5 females were injured. Of the remaining larvae, 39 males became positive and 10 compassed, while 40 females became positive and 5 compassed. Three of the positive males went half way to the light and then turned back from it. Examination showed that the threads were loosened during movement. When the threads were tightened again, the larvae became positive once more. Examination of the larvae of both sexes which compassed showed that in every case the threads did not lie directly across the anterior third of the segment. All controls in this experiment remained negative. Thus, it could be concluded that starvation affected the photic orientation of the larvae first through changes in the degree of distension of the digestive tract affecting some structure in the fifth segment of the body.

An examination of the internal anatomy of the sixth stage larva revealed that the only outstanding feature in the anterior third of segment V was the ganglion of the ventral nerve cord present in the segment. It seemed possible that relief of pressure on this ganglion by the emptying of the tract during starvation might be responsible for the occurrence of the primary reversal

noted. If this was true, it was thought that anaesthetizing the ganglion of a photopositive larva might have the same effect as the relief of pressure on the ganglion by movement of food along the tract. Accordingly, injections near this and other ganglia were carried out, using 0.002 cc. of a 4 per cent by volume solution of methylal in Ringer's solution as the standard amount of injection. Each such injection was accompanied by a control injection of Ringer's solution alone, to reveal any strictly mechanical effects which might have resulted when the needle pierced the integument or touched a nerve structure. Injection was done shallowly in the ventral portion of the particular segment in which the ganglion concerned was known to be located.

Injections of totals of 150 larvae of each sex in segments I-IV and VI-IX, with the exception of 5 females and 1 male in the Groups IV and VI, showed no change from rigidly photopositive behaviour. The exceptions noted above compassed, but consideration of the results below suggests that such compassing probably resulted from movements of the larvae at the times of the injections throwing at least some of the fluid into segment V. Segments beyond segment IX were not injected, because there was some danger of inflating the digestive tract.

Injection of 63 males and 62 females in the anterior portion of segment V resulted in 49 males and 52 females becoming strongly photonegative, while 12 males and 9 females compassed. Two males and 1 female were badly injured, but no larva remained positive. All the controls injected with Ringer's alone remained positive.

The larvae took about 5 minutes to recover from the effects of the injection itself. They then began to move with reference to the light. Those which were in a state of induced orientation remained in this state for periods of time up to 30 minutes, after which they reverted to their original behaviour. Controls injected with Ringer's solution alone required no recovery time and remained positive until the usual process of starvation produced negative behaviour. It is significant that small, "young" larvae of the instar also produced the immediate reorientation after injection, thus indicating that they possessed the same mechanism, although their relative body size was such that reversal brought about by starvation alone took a much longer time than in large larvae of the instar. Photonegative larvae which were injected in the fifth segment with methylal remained in the negative state, which was the behaviour to be expected.

It was recognized that there was a possibility that the head region might be concerned with the more direct control of photonegative behaviour. Therefore, injections of methylal were placed in the ventral surface of the throat, near the suboesophageal ganglion, and in the dorsal region of the head, near the supraoesophageal ganglion. The results of these injections were not so striking as were those of the previous series, for the two ganglia controlled a number of activities. Thus, injection of either one often produced a comatose state. This was particularly true of the supraoesophageal injections. Although the optic lobes which innervate the stemmata lie in this region, no evidence could be found that the lobes were connected with the behaviour, simply because the larvae were completely immobilized when injected. Injection of 60 photonegative larvae of each sex in the region of the suboesophageal ganglion resulted in 21 males and 21 females becoming positive and 36 males and 35 females beginning to compass. Three males and 4 females were injured. Since it has been mentioned that no photonegative larva ever returned to photopositive behaviour when left to its own devices, unless fed, these results must be considered to be of some significance. Furthermore, when those larvae which compassed were again injected, it was possible to raise the totals of positive larvae of each sex to 40 males and 37 females. The remainder became comatose on the second injection.

Caution must be observed in interpreting these results. It may be stated definitely that even the larvae which were very sluggish orientated photopositively and remained quiet in this position. If they were turned around, they reorientated positively again. Thus, it is clear that the injection changed the behaviour. However, since the head is an object of restricted volume, it does not follow that the suboesophageal ganglion was being directly affected to the total exclusion of the supraoesophageal ganglion. It may have been that injection through the throat was a better means of reaching the optic lobes without seriously affecting the remainder of the supraoesophageal ganglion than was dorsal injection. Therefore, there is no real evidence that the suboesophageal ganglion was directly involved. All that may be said is that there was a state of balance between a part of one or other of these two ganglia and a portion of the fifth segment which, through the medium of ebb and flow of pressure upon the fifth segment, resulted in internal changes which were manifested by reversals in photic orientation. Further investigation of the head calls for methods which are beyond the scope of the present work.

Photopositive larvae injected in the head region remained positive, which was the expected result. Injecting anaesthetic into both the fifth segment and the head region simultaneously produced a cessation of movement. The larvae so treated were capable of moving, but remained quiet unless disturbed. When the effects of the methylal in the body or in the head had been dissipated, the insects reorientated in that direction regulated by the region which was first to recover from anaesthetization.

The above experiments served to show the preliminary links in the chain which controlled photic orientation from within the animal. This particular portion of the problem was left at this stage, since it was felt that its proper development demanded investigations which were too far removed from the original purpose of the present one. Some attempts were made to study the effects on the region in the fifth segment of severance of the ventral nerve cord anterior to the segment, but this produced so many other secondary effects that this approach was abandoned.

(iii) The Effects of the Presence of Other Material

It is necessary to consider the observed differences in instar reactions to the presence of food or other stimuli when the larvae were responding to a discrete source of light, since these observations reinforce some of the conclusions already derived from consideration of the work in the previous sections. It is convenient to consider each instar separately in this respect.

It is generally considered that the first stage larvae do not feed, but, on the other hand, they do respond strongly to the presence of any material which provides a number of surfaces for contact. It was found that larvae moving to a light over the surface of black "Masonite" which had its outer layer split and cracked, or covered with small, crumpled pieces of paper, reacted to the cracks and the paper if their paths carried them to these things. They crawled into the folds of the objects and, if left undisturbed, proceeded to spin hibernacula. This disorientation is not to be confused with photonegative behaviour. Instead, it must be considered to be the replacement of a token stimulus by another entirely different stimulus, for larvae which were removed from the cracks were still photopositive.

The second instar did not exhibit any such immediate replacement of photic behaviour by a response to another stimulus. It did not react to foreign matter in its path to the light. Neither did it react to buds of varying stages of development placed in its path, no matter how long it had been starved beforehand. It was necessary to place the food right at the light source before any response to it could be obtained. Even when food was placed at this point, the response to it was not immediate, but, on occasion, took up to an hour to become evident.

It was possible to observe second stage larvae in jars under conditions which approximated darkness. This was done by throwing a very weak spot on the wall of a dark room and holding the jar 2 metres from the light. With practice, it was possible to see the larvae moving at random about the jar. Under these conditions, they reacted to the presence of a bud as soon as they came within body length of it. This suggests that time is required to lower the level of the intensity of the photic sti nulus in the presence of food. A larva removed from its food in light did not immediately react to the food again, but might repeat the whole process of wandering about the zone of most intense light for periods up to an hour in length. During this time it might cross and recross the point at which it finally reacted to the food.

Third and subsequent instars of the budworm in a photopositive condition occasionally reacted to foliage placed in their paths to the extent that they explored the foliage, but never began to feed upon it, eventually continuing towards the light instead. Nevertheless, compared with the lack of response by a second stage larvae confronted with an equivalent situation, this exploration constituted a very positive reaction.

Third stage larvae which were disorientated to light, and later stages which were in the compassing state, were more responsive to food placed in their paths as they moved about the b oard. After initial exploration of the foliage, which might take almost an hour, larvae in these states began to feed. An apparent anomaly arose from the fact that *photonegative* larvae did not respond to food placed in their paths as they moved away from a *discrete* source of light. This is discussed further in later sections.

With the exception of the lack of response by photonegative larvae, the observations tend to confirm the conclusion that starvation is an important factor in the reactions of the larvae to a discrete source of light. The responses to food by larvae of the earlier instars in various states of photic orientation agree well with the state of starvation implied by these orientations in the previous section. Although the photonegative larvae have been considered to be the most starved, they did not exhibit the expected behaviour. Actually, it is necessary to consider the reactions in the light of the requirements and habits of larvae under natural conditions before the whole relationship becomes clear.

(*b*) *Responses to Diffuse Light*

The reactions of larvae to diffuse light must be considered separately, since differences in behaviour were exhibited in some cases. Diffuse light, for the present purposes, may be considered to be light which came from no visible discrete source. Thus, it lacked effective direction, and only responses to differences in intensity could take place.

No suitable equipment was available with which very trustworthy direct measurements of intensities could be made. For some purposes, this fact would have greatly reduced the value of any observations which were made. However, it will be seen that it was of no great importance in the types of reactions dealt with here. Many of these reactions were exhibited in response to dark-light boundaries, and those which took place in varied intensities of light could be assessed by means which did not depend directly upon the measurement of the intensities.

As mentioned previously, larvae of all instars were positive to diffuse light over a wide range of temperature when they were confined in a temperature gradient. This light came from a 15-watt fluorescent tube which was masked with paper so that there was no measurable difference in the relative intensity along its length when the light was measured on the brass floor of the apparatus. Under these conditions, the larvae did not aggregate in any particular illuminated zone in the absence of gradients of temperature or evaporation. If they were covered by a piece of "Masonite" they moved out into the light again.

Larvae of all instars could be held at the dry end of a gradient of evaporation until they became desiccated. When it was found that larger larvae soon became photonegative to a discrete source of light, this experiment was reinvestigated to check its accuracy, since it took many more hours to desiccate the larvae than it did to starve them into the photonegative state, and the difference in behaviour to the two types of light did not at first seem possible.

A group of 100 sixth - stage larvae were placed in a constant temperature evaporative gradient similar to that described by Sokolov (20) and held in the dry end by darkening the rest of the gradient. Twenty hours later, they were removed before they became too dessicated to be active. At this time, they were all still in the lighted end of the gradient. However, when tested on the board with a single light, every one was photonegative. When they were returned to the gradient, they all collected once more in the lighted end. This experiment was repeated with 100 larvae of each of instars 3, 4 and 5, with similar results in the gradient and results characteristic of the instar with a discrete source. This suggested that the larvae were able to discriminate between the two types of light, and also that starvation did not affect the photopositive reaction to diffuse light as it did that to a discrete source of light.

The light produced by the shielded fluorescent tube was weak. Therefore, it was thought that the intensity might not have been great enough to repel the larvae, although this did not alter the fact that the behaviour was anomalous. When photonegative larvae were confined to jars and held directly beneath a 500-watt bulb enclosed in a ceiling fixture about 25 cm. in diameter, they still moved towards the light. The light at this point was 20 times as bright as the light on the surface of the gradient beneath the fluorescent tube. When the larvae were taken 5 metres away from the 500-watt light, they all moved away from it to the far ends of the jars.

At this time, 100 photonegative sixth-stage larvae were placed individually on a wooden dowel 15 cm. long. One end of the dowel was held so that it touched a 25-watt bulb just below the centre of the bulb. Each larva tested did not move away from the light but approached it and usually attempted to climb onto it. When repelleld by the heat, it moved a few centimeters down the dowel and remained facing the light. If these larvae were removed and placed on the board 30 cm. from the light, they all moved away from it.

When these photonegative larvae were placed on the light board, and the board was arranged so that their movement away from one light carried them directly into a patch of light thrown on the floor by an overhead, shielded 500-watt lamp, they moved directly into the lighted patch, although the intensity was 10 times greater facing the patch than it was towards the single lamp. If a second 25-watt lamp was centred in this patch and switched on as the larvae moved from the original light, they then changed direction so that they moved away from but between the two similar lamps, thus following a course which took them away from the lamps and the patch of light. If the second light was switched off after this turn, the larvae did not turn back towards the patch. This experiment showed that the larvae were not repelled by intensity, but by the direction of the source, since there was never any hesitation in crossing the dark-light boundary of the bright patch. It further indicated that there was no special response to the patch when the other light source was visible, since the larvae did not turn towards the patch when the centred light was darkened. On the other hand, if the original light was turned off when the larvae were actually within the patch, they remained within it if its boundaries were sufficiently well defined, thus showing a positive reaction to diffuse light.

Finally, similar photonegative larvae were taken outside on a day when heavy cumulus clouds alternately obscured and revealed the sun. Individuals

were placed on an inclined rod pointed upward in the general direction of the sun. During periods of cloud cover, they climbed up the rod towards the sky, but when the sun was revealed, they crawled down the rod, or dropped off it, falling on silk.

The preceding experiments were necessarily somewhat crude because of the lack of more precise equipment. However, they definitely indicated the important facts that the later stages of the larvae not only discriminate between the source and the intensity of light, but that the discrimination of a discrete source is controlled by a mechanism set in action during the emptying of the digestive tract, whereas the mechanism controlling the response to intensity is unaffected by the degree of distension of the tract.

Before proceeding with a description of the means by which photopositive responses to intensity or direction may be reversed, it should be noted that the responses of larvae to food or foreign matter in diffuse light were similar to those exhibited in directed light, with one exception. This was that the photonegative larvae which did not respond to food in their paths as they moved away from a discrete source of light did respond to it when they came near to it in diffuse light. These points must be considered in relation to the habits of the larvae in the field.

(c) *Reversal Of Light Reactions By High Temperatures*

(i) Laboratory Observations

It has been mentioned that larvae remained positive to diffuse light regardless of the evaporative rate or the length of time of the exposure at room temperature. On the other hand, it was known that larvae could be drawn along a gradient of temperature, by light only up to a certain upper limit of temperature, after which they appeared to be repelled by the temperature. At the time these observations were being made, it was also noticed that larvae which penetrated this upper limit of temperature for a moment tended to move into any shaded area which was available. All these facts were used as a basis to investigate the effect of high temperature on the reactions to light, and to evaluate possible effects of excessive evaporation at very high temperatures. The following preliminary experiments were performed.

The temperature gradient apparatus, to be described in detail elsewhere, consisted essentially of a closed chamber with a brass disc serving as the floor. If this disc was heated at the centre, but not cooled at the edge, it was possible to obtain a disc-like zone some 12 cm. wide in which the temperatures were all above 36° C. If half of this zone was covered with shadow from a piece of "Masonite" and the other half illuminated by diffuse light, it was found that instars 2 to 6 dropped near the centre of the illuminated portion entered the darkened portion as soon as possible. The smaller instars did not move very easily at these high temperatures, so their progress was rather uneven. Nevertheless, all movements were directed towards the shaded zone.

If the shading was so arranged that the centre of the gradient, above about 38° C., was darkened, while all the rest of the gradient was left illuminated, larvae introduced above 36° C. moved into the darkened area, even when this meant moving to a higher temperature. They remained in this region until paralyzed by the high temperature.

Although this type of experiment indicated that temperatures above a certain limit acted to produce a photonegative response to diffuse light, it did not rule out the possibility that greatly accelerated rates of evaporation entered into the mechanism behind the reversal. Therefore, to evaluate the role of high evaporation in this reversal, the following experiment was performed.

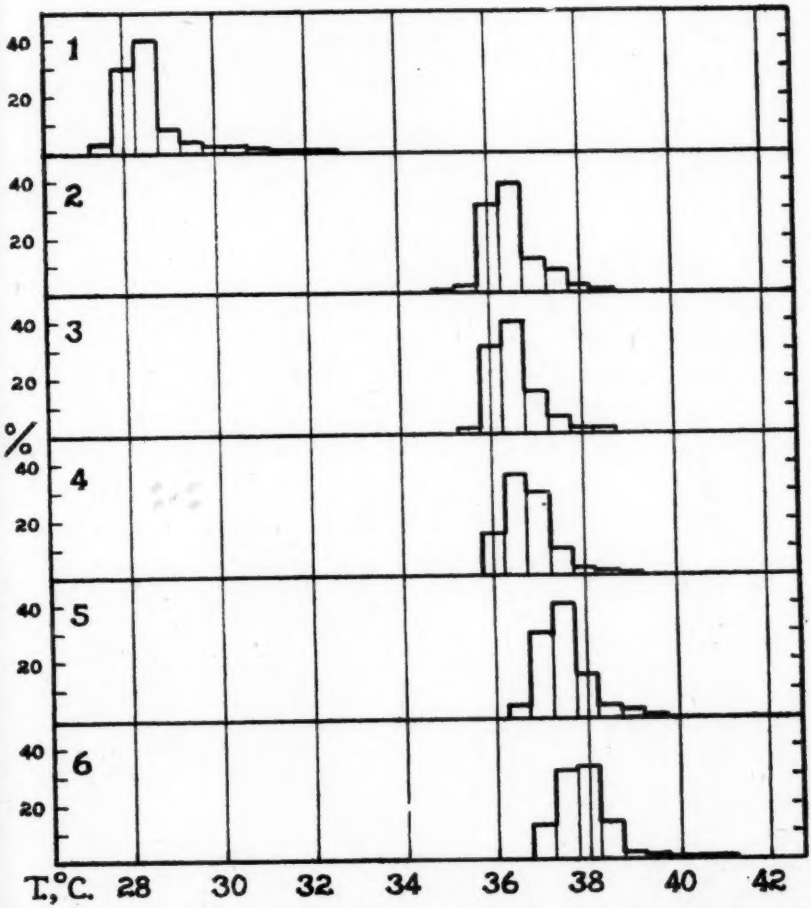

Figure 2. The reversal of photic orientation at high temperatures: inter-instar comparison of the ranges of temperature in which larvae of instars 1 to 6 acclimated to 20.6°C. became photonegative, even in saturated air. Ordinate: percentage frequency; abscissa: temperature, Centigrade.

A 2000 cc. beaker was partly filled with water. A zinc strip about 1 cm. wide was bent into a ring which could be fitted snugly into the body of the beaker. Cotton gauze was stretched tightly over the ring and folded under its lower edge, and the whole was then torced down into the beaker so that it came to rest about 3 cm. from the top. This assembly provided a floor on which larvae could move without dropping into the water beneath. A composite roof was then fashioned of glass and black "Masonite", taped together at the boundary. The roof was large enough in area so that approximately equal parts of the floor were shaded and illuminated. This roof was sealed in position with a grease seal during an experiment. A thermometer or thermocouple was inserted through the small space left by the lip of the beaker. By heating the water slowly with a gas flame, it was possible to raise the temperature of the enclosed air space and, at the same time, keep the air thoroughly saturated. Thus, any changes in the light reactions of larvae enclosed in it could be attributed to the effects of temperature alone. The whole apparatus was illuminated from above with diffuse light and shielded around the sides with cardboard which could be removed under the darkened side of the roof.

Larvae of all the instars were tested in this apparatus. It was necessary to raise the temperature quickly because saturated air immobilized the larvae rapidly, so none of the experiments lasted longer than thirty minutes. For all instars but the first, it was found preferable to keep the temperature of the water at about 30° C. and leave the roof off while preparing for a test so that the air was not initially saturated. This kept the larvae from becoming immobilized while the temperature was being raised to and above a critical point.

The reactions of any larvae in this equipment were characteristic in pattern. Upon introduction into the enclosed space, and during the time the temperature was being raised, all larvae remained in the illuminated area. However, at the critical range of temperature, which varied somewhat with the instar, the larvae moved into the darkened portion of the chamber and remained there until the temperature was lowered again. All the larvae did not move together to or from the darkened portion, so that the critical temperature of an instar had to be considered as a small range, rather than as a point. Orientation from one half to the other was direct, once the larvae began to move. The ranges of temperature through which 100 larvae of each instar reversed from photopositive to photonegative are shown in Figure 2 and the means are listed in Table 4. In all these tests,the larvae were taken directly from containers at room temperature without being acclimated to higher temperatures (*cf.* Fry (13)).

Table 4. Inter-instar differences in the mean temperatures at which spruce budworm larvae acclimated to 20.6° C. became photonegative with respect to diffuse light.

Instar No.	1	2	3	4	5	6
n	100	100	100	100	100	100
x	28.6	36.5	36.5	36.8	37.5	37.9
s	0.9	0.6	0.6	0.6	0.6	0.7
Sx	0.09	0.06	0.06	0.06	0.06	0.07

Note: Chi-square tests of paired distributions showed that instars 2 and 3 exhibited no significant difference (P=0.96), while all others differed significantly (P=0.01). n, number; x, mean; s, standard deviation; Sx, standard deviation of mean.

The striking difference between the reversal ranges of the first and second instars is also shown by the actions of larvae in a temperature gradient as illustrated in the sample tracks of Figure 3. These tracks also show the external mechanism of the reaction.

For experiments of this type, the room was darkened and the centre of the gradient was illuminated by a spot of light from an overhead lamp. A dia-

phragmed microscope lamp was so arranged that it cast a narrow pencil of light from the centre to the periphery of the floor of the gradient. Larvae were placed in a cool zone of the gradient near this beam, and immediately travelled to the beam and along it towards the bright, central spot. The path of any larva was direct, as shown in Figure 3, until the critical temperature was encountered. At this point, the larva then turned sharply away from the light, a process which took it to a lower temperature in the gradient. Whatever process caused the photic reversal to occur at high temperature subsided within a minute at temperatures below the critical zone, for the tracks show how a larva quickly reorientated to the central spot, turning away once more when it reached the critical temperature zone. This procedure could not be changed in the first two stages, and it continued in the later stages as long as a larva remained photopositive to a visible source of light. The sample tracks in Figure 3 also show that, for any one larva, the reversal temperature is not a point, but a small range, just as it is for a group of larvae. Such tracks also serve to show, for later instars not illustrated here, but which have the same type of tracks, that besides the reversal of response to intensity of light by high temperatures illustrated by the waterbath experiments, orientation to directed light is broken down by high temperature as well as by hunger.

(ii) Field Observations

During 1946, a hypothesis was put forward relating the effects of high temperature on the behaviour of larvae in response to light as observed in the laboratory to certain weather conditions which appeared to be associated with mass dropping or migrations of larvae under natural conditions. This has been referred to briefly in a recent publication (Wellington and Henson (21)) and will be dealt with in considerable detail in the discussion of the present paper. At the time the hypothesis was first put forth, there was some doubt whether larvae under field conditions could ever experience temperatures which were high enough to correspond to the reversal temperatures observed in the laboratory. Consequently, it was necessary to carry laboratory methods to the field to determine the temperature ranges encountered by mature larvae established in feeding sites.

The larvae of the spruce budworm feed chiefly on current vegetative growth of the host tree and commonly web several needles together to form a silk-lined tunnel in which they rest while feeding. It was necessary to compare the body temperatures of sixth instar larvae to the temperature of the air enclosed in a tunnel and to the temperature of the air outside the tunnel. An indicating potentiometer was employed with a number of single-junction copper-constantan thermocouples set at the required points. Since the readings extended over a period of several hours on a site exposed to direct July sunlight, water at 20° C., rather than ice, was used in the reference bottle, which was buried to the cork in the earth and artificially shaded from direct sunlight. After recalibration of the couples for the reference temperature, this arrangement worked very well.

Body temperatures of sixth instar larvae exposed directly to the rays of the sun or enclosed in foliage tunnels were determined by inserting an indicating junction into the digestive tract through the anus. This procedure required a certain amount of practice on the part of the operator, as well as a good deal of forbearance on the part of the budworm, but, with care, measurements could be obtained from the region of the midgut without apparent injury to a larva.

The results obtained are more directly concerned with studies of the temperature relations of the insect, but, for the present purpose, it is of considerable interest that, despite unsatisfactory weather conditions, it was possible to demonstrate that a larva in the field could actually experience temperatures in the reversal range observed in the laboratory. In direct sunlight, body temperatures

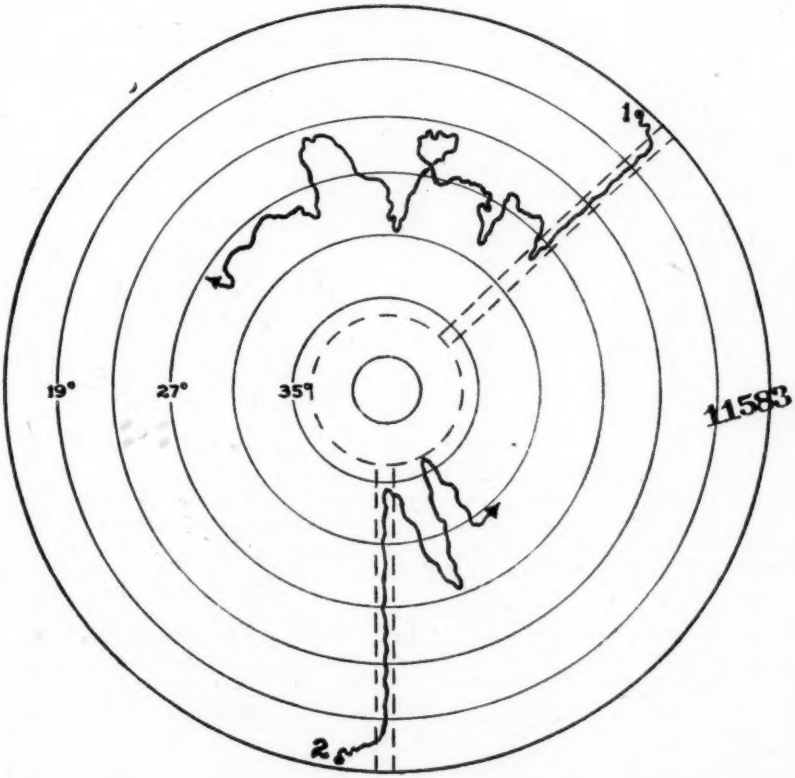

Figure 3. The reversal of photic orientation at high temperatures: sample tracks of larvae of instars 1 and 2 showing the actions of the larvae in the ranges of temperature in which reversal occurred. Dotted lines enclose lighted zones of a temperature gradient. Disc figures: temperature. Centigrade.

of both exposed and concealed larvae usually were above the free air temperatures. Body temperatures of exposed larvae ranged at times to almost 3° above free air temperatures under the influence of radiation, despite rapid evaporation. Of greater significance, however, was the fact that tunnel air temperatures ranged up to 5° above free air temperatures (even greater differences have been observed since these initial observations) under direct insolation and the body temperatures of concealed larvae ranged a further 3°-4° above the tunnel air temperatures. Thus, for instance, although an outside air temperature was only 28.2° C., the tunnel temperature was 32.7° and the larval body temperature was 37° C., which lies just on the lower limit of the range for the sixth instar observed in the laboratory. Since tunnel temperatures over 37° have since been observed when no larvae were available, it seems clear that mature larvae under natural conditions stand an excellent chance of experiencing temperatures within or above their reversal range.

(*d*) *Optomotor Responses*

Some of the preceding work pointed to perception of the form of a source of light. Therefore, some experiments were performed in order to determine whether any reactions observed would indicate a type of form vision. All experiments were done under diffuse light.

The first experiments were done in an arena 25 cm. in diameter. Either black or white backgrounds were used, and figures of appropriate contrast to the backgrounds were placed around the wall. These figures were both bi- and tri-dimensional, and their forms were varied as to the width, height and slope of the lines forming the sides. Sizes ranged from 2 mm. to 8 cm. for base lines and from 2 mm. to 10 cm. for perpendiculars. Further description is unnecessary, for these stationary figures evoked no response.

On the other hand, if the walls of the arena were made solidly black, response to a moving white square not less than 3 x 3 mm. in size was excellent, provided the square was moved from side to side not more slowly than 3 times per second. Photopositive larvae at a distance turned through 90° and moved directly towards the square, stopping directly below it and reaching up towards it. Small larvae moved from distances up to 7 cm., and large photopositive larvae moved the width of the arena towards the square. Orientation to a moving, small black square on a white ground could not be demonstrated with photonegative larvae.

Larvae did not respond to stationary stripes of any width. However, if stripes were moved under them as they crawled on a glass plate raised a few millimetres above the striped paper to eliminate frictional vibrations, reactions did occur under certain circumstances. If the long axes of the stripes lay in the same direction as the long axis of the body of a larva, no reaction took place, and the larva continued to move normally. However, if it turned during the course of its movements, or was initially so placed that its longitudinal axis lay at right angles to the stripes, response to movement of the stripes was immediate. The larva stopped and performed lateral movements with the anterior portion of its body. If the stripes were moved back and forth at rates of not less than 3 times per second, and the body axis lay across the stripes, the larva seemed unable to move forward. However, if the stripes were being moved only one way, or if the head was turned through 90° during the course of a lateral deviation of the body so that it was brought into line with the stripes, the larva began to move again. It should be noted that one-way movement of the stripes did produce a reaction, but the larva was not held by the movement. Best results were obtained by using stripes 2 to 5 mm. wide spaced at 3 to 4 mm. intervals. If similar stripes were painted on glass, and this was moved over larvae on a table, they reacted in the same way as noted above. In other words, while they were on a plane surface, they always responded by lifting their heads whether the stripes were above or below them.

If one wall of a square arena was replaced by a strip of vertically striped paper which was moved back and forth as larvae moved in line with it, such larvae reacted by turning through 90° and moving directly towards the stripes. Once more, stripes of the same widths and intervals noted above produced the best results. When larvae came within 2 mm. of the moving paper, they turned and moved along beside it. Responses to stripes moving in one direction did not take place.

When larvae were placed on a thread stretched between two dowels 10 cm. above a table, they responded to stripes moving above or below them by bending up or down, depending on the position of the stripes. This behaviour was at variance with that observed on a plane surface, where the head was always lifted, whether the stripes were above or below the working surface. If a twig of balsam was substituted for the stripes when the larvae were on the thread, the insects responded to its movements in the same way.

(5) ADULT REACTIONS

Investigations of the light reactions of spruce budworm adults centred around observations of the responses of both sexes to discrete sources of light, chiefly because of the current interest in trapping specimens in regions of light infestations.

The first series of tests were made with the two-light board previously described. Fifty adults of each sex from each of the five forest districts were tested with twin lights. In this and subsequent types of tests no differences in the responses of individuals from different localities were observed, despite the fact that the North Bay material came from a light infestation and the other four collections were obtained from areas of heavy infestation. On the other hand, distinct sex differences were observed, and, in this respect, the adults differ from larvae.

Males crawling on the board were consistently photopositive, producing a typically balanced distribution with the peak along the central 0° orientation angle. Crawling females were consistently photonegative, producing a reversed distribution still centred at an orientation angle of 0°. Tests of additional sets of 50 individuals of each sex from each locality with single lights produced similar paths directly to or from the light, depending upon the sex of the individual.

It was found to be impossible to continue a series of trials, such as those performed with larvae, because, after two or three trials, any adult became sluggish and came to rest, moving with difficulty even when prodded. The directions taken by disturbed males varied so much under these conditions that it is permissible to consider them as being indifferent to light. Females became so sluggish that, for practical purposes, they could be considered immobilized.

Storage of any individual in complete darkness for about five minutes reactivated it, and two or three more trials could be completed. Similarly, decreasing the light intensity immediately an insect ceased crawling started it moving again, within a minute, if it was prodded. Within 3 minutes after the lower intensity was presented to it, movement ceased once more. It could be initiated again by a further decrease in the light intensity, the cycle being repeatable down to intensities approximating darkness. Raising the intensity when an insect was moving usually decreased the time of movement, and raising the intensity when an insect was stationary kept it immobilized. Thus, unlike the larvae, the adults of the spruce budworm adapted rapidly to any level of intensity.

The usual external evidence for pigment migration appeared on examination of the eyes of living adults in various states. The eyes of photopositive males glowed with light reflected from the tapetum. The eyes of adapted males

and those of the actively photonegative or immobilized females reflected very little light, and so appeared duller and rather opaque.

Reactions of flying males to light were identical with those of crawling males. Until recently, there has been some question as to whether or not spruce budworm females were capable of active flight, and this point had to be investigated before the present observations could proceed. For the present purposes, the results may be summarized as follows: mated or unmated females which are gravid (i.e.:- carrying their full complement of eggs) are completely incapable of *active* flight; ovipositing females, which have dropped some eggs and will continue to do so can fly as well as males; spent females, whether carrying or lacking eggs are too weak to fly.

When ovipositing females were tested with a single light while in flight, a different response was sometimes observed. Ordinarily, flying females reacted negatively to the light source, just as they did when crawling. However, occasionally an individual which had just responded with a directly negative orientation would, on the next trial, compass by the source, and, at the close quarters in the room, the spiral track led it to within about a foot of the source, at which point it folded its wings and dropped abruptly. This point was investigated further, but no orderly appearance of the light-compass reaction could be detected. Any flying female tested sometimes reacted in the way described above, but there was no relation between the behaviour and the number of trials, continuing oviposition, age or locality. Furthermore, attempts to modify the behaviour by injections of anasthetic into different segments or by cutting the nerve cord at different points gave no unusual results.

(6) DISCUSSION

The fact that most of the later stages of the larvae of the spruce budworm reverse their orientation to a discrete source of light from positive to negative is interesting but not unusual enough to require much comment. The discovery that this change is first produced by a mechanical effect of starvation is of interest chiefly in particular ways, some of which will be discussed with reference to the observed actions of larvae in the field. From the standpoint of generalities, the mechanism involved suggests a possible explanation of the actions of certain diseased lepidopterous larvae. For instance, it has been known for some time that larvae of *Lymantria monacha* L. show a tendency to move to the tops of trees when afflicted with a polyhedral virus disease. The disease, in fact, is referred to as "Wipfelkrankheit", in reference to this tendency. Diseased larvae which move to the tree tops are swollen and turgid. It has been shown here that larvae of the spruce budworm are strongly and rigidly photopositive to either the source or the intensity of the light when they are in a condition of normal or induced firmness, the latter of which may approximate a turgid state. Thus it seems possible that the course of disease in *Lymantria* affects these caterpillars in the same way that artificial or normal distension of the digestive tract affects the budworm. In other words, rigidly photopositive behaviour results in both cases.

Several other interesting parallels occur between the observed photic behaviour of *L. monacha* and that of the spruce budworm. For instance, Brandt (2) reported that the young larvae were photopositive, but became indifferent to light during feeding, while some of the last stage larvae were photonegative. Brandt (1) also remarked on the fact that young larvae became photonegative at high temperatures. These observations, in addition to the ones on diseased larvae, suggest the European species should be subjected to a series of tests similar to those reported here. The problem seems worth investigation by those interested in the European species.

The apparent relationship beween the eyes and the ganglion of segment V at first glance seems somewhat unorthodox. Nevertheless, while *Lymantria*

appears to be a useful species for additional tests, it may be possible to demonstrate the relationship, or a similar one, in additional species of lepidopterous larvae. For instance, Brecher (3), using *Pieris* and *Vanessa* spp., demonstrated that light irritation during the larval stage influenced the colours of future pupae, and that the stimulus appeared to be directed from the eye through the ventral string ganglia and lateral nerves. Thus, tests of such species might extend the number possessing the mechanism, or reveal modifications of it.

One of the most interesting of the theoretical points which have emerged from the preceding study is the fact that late stage larvae remain positive to diffuse or scattered light when they become negative to directed light from a discrete source. Consideration of the life history of the budworm suggests that this is also of some practical significance, so it will be dealt with in some detail.

It is possible to interpret these apparently opposite responses in several ways. The usual method of approach is to assume that even the directed responses exhibited by caterpillars are, in the final analysis, performed by reactions to differences in intensity. This approach is usually taken in deference to the accepted theory that the visual apparatus of caterpillars is too primitive to detect much except differences in intensity, except, perhaps, at very close range.

This attitude is in accordance with the principle of parsimony, and may lead to valuable conclusions so long as the behaviour of an animal is well-defined. Thus, if an insect goes directly to or from one light and between two lights, it may be assumed that it is able to do so by simultaneously comparing the intensities impinging on the paired receptors. Similarly, even if an insect does not respond to one of two lights, it may be argued, on somewhat less certain grounds, that it is still the intensity, or quantity of light falling on one set of receptors which is temporarily inhibited. On the other hand, when an insect remains positive to intensities and is at the same instant negative to direction, or does not respond to one of two discrete sources, the usual method of approach begins to break down. A further assumption concerning the efficiency of its receptors is necessary.

This additional assumption is necessary because it is evident that an insect which orientated by means of comparing intensities would be forced to approach a source of light so long as it remained positive to intensity. If such an insect moves *away* from the light source, but is not repelled by diffuse light of an intensity *higher* than in the direction of the radiating source, then it must be orientating to or away from the source by means other than intensity. It seems necessary to assume at least a primitive type of perception of distant images of certain kinds.

The photonegative larvae of the budworm behaved exactly in the way noted in the preceding paragraph. Further consideration of their behaviour provides additional information. When photonegative, they moved away from the disc of the sun, but moved towards the clouded sky. Since the sun was brighter, this provides no direct information. However, when held directly to a lamp, they tried to climb onto it, whereas they moved away from it when they were placed at a distance from it. Since the intensity right at a radiating source is the highest of a series of intensities available, it does not seem that these two types of reactions were consistent with the assumption that the insect orientated by comparing intensities. Instead, they suggest that receptors which were negative to a perceived bright image became inoperative when they were so close that they could no longer perceive an image as such, but were illuminated more or less evenly by a patch of diffuse light too large for them to resolve into an image. It seems reasonable to assume on these grounds that at least some of the lateral ocelli of the larvae were capable of perceiving a disc-like, bright object as such.

The evidence presented above constitutes the most direct evidence suggesting the perception of a point of light as such rather than as an increase in intensity. In addition, the actions of individual larvae were not always consistent with what is considered to be typical behaviour of animals possessing eyes as primitive as those of caterpillars are thought to be. Consider the fact that the compassing sixth stage larvae shown in Figure 1 compassed by either light. Theoretically, they should have struck a resultant course between the two lights if they were typical caterpillars. This was investigated further, and it was found that such larvae might or might not respond to a second light if it was switched on while they were compassing by a single light. Further, the inhibition was performed by using the eyes on each side of the head, one set being used for each light. This behaviour is not at all consistent with that expected of caterpillars (*cf.* Ludwig (17, 18); Fraenkel and Gunn (11)).

The chief theoretical objection to any assumption that lepidopterous larvae can perceive form at a distance is that their dioptric apparatus is, at best, crude, and has no power of accommodation. This is true, but the perception of a bright disc as such, or recognition of a dark - light boundary requires no very high degree of visual acuity. All that is required is that some resolution be obtained, as opposed to a patchwork of intensities, and that this be carried to and received by proper percipient apparatus. The evidence indicates that this occurs at least during the times larvae are in compassing or negative conditions, and the optomotor experiments, while not discounting discrimination of differences in intensity, indicate that the ability to discriminate a sharply defined dark-light boundary of short length at some distance is present in all stages whether photonegative behaviour occurs in these stages or not.

As regards the dioptric apparatus alone, Dethier (7) has shown that two types of corneal lenses may be present in the stemmata of lepidopterous larvae. He considered that the possession of lenses capable of transmitting images was not sufficient evidence to indicate the perception of images, stating in a later paper (8) that the shape of the rhabdom of an ocellus was inadequate for the reception of images. However, he did consider that the movements of advancing larvae might make possible a primitive type of form vision.

It has been shown that it was possible for the observer to produce a change in photic orientation to a discrete source at will, simply by treating the larvae in the proper way. This suggests that the apparatus used to perceive the image of the light may not be functional at all times, but is brought into operation by certain conditions In the spruce budworm, these conditions are established by emptying the digestive tract until an unknown increment of pressure has been removed from a portion of segment V. The dioptric apparatus is fixed, but consideration of the above remarks suggests that some change in the underlying structures takes place. Lammert (16) reported that migration of pigment could not be demonstrated in the stemmata of lepidopterous larvae. Nevertheless, it would be of interest to reopen this problem, considering the findings reported here. This indicates one form of future research, but caution is necessary, for more obscure processes might be involved.

Some problems requiring further investigation in this particular field may be outlined. A histological examination of eyes with both bi- and tri-partite lenses, particularly those of sixth stage larvae, is required. Material should be fixed when larvae are rigidly photopositive, compassing and photonegative, and any differences in the eyes noted. Moreover, a comparison of the internal and external structures of the eyes of the first few stages with those of the sixth stage is necessary.

It is interesting to note that *Lymantria monacha* L., previously mentioned in connection with the possible effects of "Wipfelkrankheit", exhibits some well-marked reactions to dark-light boundaries (Hundertmark (14)). The chief difference between its reactions and those of the budworm is that the latter did not react to the presence of stationary objects, while *Lymantria* did so commonly.

The optomotor responses of the budworm, whatever their basis, seem to be largely responses to stripes which in their smallest widths closely approximate the widths of the needles of balsam. The typical lateral movements of the head exhibited also are shown best when the stripes or foliage are moved back and forth as they would be by wind in the field.

The reversal of photic orientation at high temperature is not uncommon in insects (*vide* Dolley and Golden (9) for a recent bibliography). So far as the sixth, and possibly the first and fifth stage larvae of the spruce budworm are concerned, reversal to a completely negative response to both the direction and intensity of light has a definite survival value, of the type suggested by the observations of Jack and Williams (15) and Mellanby (19) on *Glossina* spp. It has been shown that larvae under natural conditions experience temperatures resulting in negative responses, and it is known that the reversal ranges lie at least partly within the lethal ranges of temperature, although their relation to the incipient lethal levels (Fry (13)) has not yet been determined. Field observations on the movements of individual sixth stage larvae have shown that larvae in nests on the exposed face of a tree either drop to shaded levels or retreat to the inner, shaded portion of a branch during periods of exposure to intense radiant heating. As indicated in a previous note (Wellington and Hanson (21)), larvae performing the latter movements do not always return to the same feeding site, so that one individual may be responsible for the partial defoliation of several shoots, thus producing sampling difficulties. Presumably, similar temperature - induced intra-tree migrations of fifth stage larvae may occur, although this and similar points are still under further study by W. R. Henson.

Some further indications of the adaptation of the spruce budworm to its environment have been included in the preliminary note (21) cited above. Nevertheless, it is necessary to include additional material in this paper in order that the significance of the relation of starvation and its effects upon photic orientation to mass migrations of larvae may be fully understood. It is necessary to consider the conditions which arise in areas where the spruce budworm reaches epidemic proportions. Although actual feeding by individuals is light in the early stages, populations may be so heavy that few buds in the top and middle portions of the trees are unoccupied. It is as yet uncertain just how much actual starvation under these conditions may occur in the third and fourth instars, when some migration to new feeding sites must take place. However, even if starvation did not occur in these stages, it certainly would occur in the last two stages of the larval period unless some mechanism existed by which at least some of the population could be directed elsewhere. If any of these stages were as rigidly positive as was the second instar, they would be confined to the top portion of the tree by their response to light.

It has been shown that an increasing interval of enforced starvation acts on most of the larvae tested by producing mechanical effects which aid in changing the photic orientation to a discrete source of light. The reactions which ensue must be regarded with reference to field conditions. The northern Ontario outbreak from which the material used here was obtained may be used as an example. The case of a hypothetical sixth stage larva will be considered.

If this larva were a member of a heavy infestation, it would, on leaving its defoliated shoot, have little chance of encountering a twig in any better condition. The larva would definitely not remain on the original, defoliated shoot if the evaporative rate were high enough to permit activity. In fact, it was found in subsidiary work that a high rate of evaporation induces a greater amount of activity. Since no larva ever seems to have a very secure foothold while in motion, the increased amount of movement would result in the larva eventually dropping on silk. However, as long as it remained photopositive, it would move upward again, if it did not actually strike fresh foliage on the way down. Thus, its photopositive orientation would not be very productive.

As starvation progressed, the larva would be capable of compassing by the sun when this was in sight. In nature, this could only result in a movement around the tree instead of up it. This movement would increase the chances of finding food. If the day was dry and overcast, the larva would lack a discrete source of light and its movements would be directed only by diffuse light, which would be relatively uniform over the top of the tree. If the overcast conditions persisted long without rain, the larva would be held in the zone around the top of the tree However, in the season and the area under consideration, overcast skies soon lead to showery precipitation and subsequent clearing.

Assuming the rapid return of sunlight, it will be seen that the larva when it had been starved sufficiently would become negative to the disc of the sun. This would drive it down the tree until it had moved by crawling or dropping out of sight of the disc. This type of dropping would *not* be followed by a return to any higher level from which the disc of the sun was visible. However, once the larva was below this point, since it would still be positive to *diffuse* light, it would be held in the outer portion or the periphery of the tree, where the population on the new foliage was relatively light and where the chances of encountering fresh food were good. If this larva were photonegative to intensity as well as to the disc of the sun, it would be driven in towards the trunk of the tree where no food exists.

All these changes in orientation seem to have rather convenient results, on the face of things. The reader may question the above statements, but they do fit observed behaviour in the field and show how the observations in the laboratory may explain this behaviour. There are, however, certain facts which must be noted.

Dropping may occur because of the action of other factors, such as the temperature effects already noted. It should be realized that negative behaviour to the disc of the sun could occur only when insolation values were below the maximum range. Moreover, there is some field evidence that strong winds occurring at the time larvae are wandering will produce dropping whether direct sunlight is present or not. Also, sudden, sharp showers will flood tunnels, drive larvae out before they become immobilized by the saturated air, and knock them off the twigs on which they rest. These types of dropping must not be confused with the type outlined above.

Sixth stage larvae often are observed dropping to or wandering in the lower levels of the trees. They may, on occasion, be found in quantity on the forest floor, particularly in very heavy outbreak areas. These larvae have been observed to climb back up the trees. This is in no way inconsistent with the above statements, in that they are still positive to diffuse light, which is coming from above. The wandering on the forest floor may result in enough spreading so that larvae are dispersed over a somewhat larger area before they again climb trees. Thus, the whole mechanism is one which would normally occur under overcrowded natural conditions, but which exists in individual larvae and can be produced experimentally by imposing starvation which, in the field, would be one of the results of crowding.

One thousand photonegative sixth stage larvae were observed in the experiments reported here. It was noted in the results that only 30 larvae were found which did not become negative to a discrete source of light. These were culled during collections of photonegative larvae for the injection experiments. It would be of interest to examine the photic responses of sixth stage larvae in known endemic areas and in areas left in the wake of an epidemic, and to compare the reactions of these larvae with those of individuals collected directly from an epidemic area and tested without further rearing. Such observations might provide information on whether the numbers of sixth stage larvae indifferent to light were insignificant in all types of areas, or whether some types of areas showed significant increases in the numbers of these larvae.

The light reactions of the adults require little additional comment to that included in the preliminary note (21). Collins (6) has investigated the relation of pigment migration to activity level in adult *Carpocapsa,* finding that full adaptation to either light or darkness produced a cessation of activity similar to that described for spruce budworm adults fully adapted to light. The consistently photonegative behaviour of crawling females appears to be related to the selection of sites for oviposition on the host trees (J. J. Fettes, personal communication). Preliminary samples taken during purely statistical population studies still in progress indicate a tendency towards the deposition of larger numbers of egg masses upon the side or portion of a tree least exposed to light during the daily oviposition period. Although further observations are desirable, from the statistical point of view, the indicated tendency is not surprising, in view of the observed behaviour of the females.

(7) CONCLUSIONS

1. All larval stages were at first positive to a discrete source of light. The first two stages retained this orientation under all conditions at room temperature.
2. Instar 3 became indifferent to light when starved, while the last three instars during starvation first performed light-compass orientations and then bebecame photonegative. Unless fed or specially treated, they remained so.
3. Photic orientation could be changed by experimental means. It was shown that larvae were photopositive when the digestive tract was naturally or artificially distended, or if external pressure was applied to the fifth segment of the body. Compass reactions or photonegative behaviour occurred when the digestive tract began to empty or when the C.N.S. ganglion of segment V was anaesthetized.
4. All larval stages were positive to diffuse light at room temperature, even if negative to a discrete source of light.
5. All larvae became negative to both the direction and intensity of light at high temperature. The limit for the first instar was about 28°., that for instars 2 and 3 was about 36° C., and those for instars 4, 5 and 6 ranged from 37 to 38° C.
6. Optomotor responses to moving stripes and small contrasting squares were demonstrated with larvae in the photopositive state.
7. Larvae negative to a source of light were not repelled by diffuse light of intensities higher than that of the source. This suggested a primitive type of image formation.
8. Crawling or flying adult males were consistently positive to light, but bebecame adapted rapidly to any intensity, and became inactive.
9. Crawling females were negative to light, adapting to it and becoming inactive just as did the males. On the other hand, flying females at times performed light-compass orientations.

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VARIATIONS IN FALL EMBRYOLOGICAL DEVELOPMENT IN THREE GRASSHOPPER SPECIES[1]

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A study of embryological development in grasshopper eggs was made as a part of a general study of the effect of weather on the seasonal development of grasshoppers. The variation in the stage of development in which eggs of *Melanoplus bivittatus* (Say), *Melanoplus mexicanus mexicanus* (Sauss.), and *Camnula pellucida* (Scud.) entered the winters of 1941 to 1947 in different areas of the Prairie Region of Canada is presented in the following paper.

The eggs of these grasshoppers are normally deposited during the late summer and early fall (late July to early October). They spend the winter covered by from one-half to two inches of soil and hatch during May and June of the following spring. The egg laying period, as well as the time of hatching, varies considerably in the different species, and from year to year depending upon the seasonal weather conditions. *Camnula* eggs are deposited over a relatively short period during late July and early August. *M. bivittatus* and *M. mexicanus* egg deposition extends over a much longer period than that of *Camnula*. The majority of the eggs of *M. bivittatus* are deposited during August and in some seasons during the first part of September. *M. mexicanus* eggs are deposited during late August and early September but deposition may continue on into late September and October. Low temperatures preclude the possibility of embryological development continuing during the winter season.

MATERIALS AND METHODS

Collection of material

Grasshopper egg pods were collected in the fall when development was considered to have ceased. In Manitoba and Saskatchewan the collections were made about October 15 and in Alberta about November 1. The eggs were placed immediately in 70% ethyl alcohol, or kept on ice, to stop development until they could be examined. Each pod, or a sample of it, was placed in a separate vial to facilitate examination.

Examination of material

In preliminary investigations the embryos were examined by cutting off the micropylar end of the egg and squeezing out the contents into water in a watch glass or onto a microscope slide as described by Slifer (1).

It was later found that the eggs of *M. mexicanus* and *M. bivittatus* could be cleared by leaving them in turpentine for 8 to 10 days. Those of *C. pellucida* could similarly be cleared in benzene. After 10 days in benzene or turpentine the yolks of the eggs began to shrink and the eggs gradually deteriorated. It was found that eggs collected and preserved in 70% alcohol could be cleared by the above solutions when required. After being cleared the embryos could be observed within the eggs and classified as to stage of development with the aid of a dissecting microscope using transmitted light. The methods developed permitted the preservation and examination of a considerable quantity of material.

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Classification of embryos for development

The grasshopper embryos were classified as to stage of development by comparing them with the diagrams of the morphological stages of *M. differentialis* (Thom.) embryos of known temperature history as presented Slifer (1). (See also Steele (2)). Slifer's diagrams were first adapted by D. S. Smith[1] for use in preliminary experiments on the embryonic development of *M. mexicanus* at Lyleton, Manitoba in 1938. In the present paper, Smith's table has been slightly modified. The thirty-seven day stage of development of Slifer has been taken as 100% development. Stages at 10% intervals have been described from Slifer's drawings on this time basis as follows:—

10% — Slifer, Figs. 1 and 2 — 5 to 6 days development at 25 degrees C., an embryonic disc appearing at posterior end of egg (micropylar end).

20% — Slifer, Fig. 4 — 8 days development at 25 degrees C., tail two or three times length of head, segmented at upper end. Embryo growing along ventral surface of the egg (anatrepsis).

30% — Slifer, Fig. 7 — 11 days development at 25 degrees C., complete abdominal segmentation.

40% — Slifer, Figs. 11 and 12 — 15 to 16 days development at 25 degrees C., legs starting to show constriction at joints.

50% — Slifer, Fig. 15 — 19 days development at 25 degrees C., hind tibia folded up, head still at posterior end of the egg with the embryo lying along the ventral surface.

60% — Slifer, Fig. 20 — 15 days before hatching, embryo growing around end of yolk (blastokinesis), eye crescents starting to appear. Embryo turns on its long axis (revolution) to bring its ventral surface again to the ventral side of the egg.

70% — Slifer, Fig. 22 — 11 days before hatching, head of embryo approaching anterior end of egg, femora not more than half length of abdomen. Embryo growing dorsally and anteriorly. (Katatrepsis)

80% — Slifer, Fig. 23 — 6 days before hatching, head of embryo at anterior end of egg, hind femora nearly full length of abdomen. Yolk enguifment practically completed.

90% — Slifer, Fig. 24 — day of hatching, spines appearing on hind tibiae, pigmentation setting in.

When a group of pods, generally forty, had been examined, the percentage development of that collection was calculated by multiplying the percentage in each stage of development by one for 10% developed, two for 20%, etc. These products were then added and the sum divided by ten to give the percentage development for the collection. The percentage development figure is equivalent to the mean stage of development of the embryos in the collection.

The percentage embryological development classes are based on Slifer's data for *M. differentialis* in which hatching, omitting diapause, occurs 37 days after oviposition when kept at a constant temperature of 25°C. There is no assurance that the time in days will be the same for the development of species other than *M. differentialis.*

RESULTS

A summary of the data for the years of 1941 to 1947 is presented in tables 1 to 3. The left half of each table shows the developmental value in percent, or the average development of the collections, and the right

[1]D. S. Smith, Agricultural Scientist, Dominion Entomological Laboratory, Brandon, Manitoba.

half shows the percentage of pods in the higher categories of development. In the case of *Camnula* (table 1) the right half of the table shows the percentage of pods in the 40% and 50% stages of development, that is, the stage just before blastokinesis. In tables 2 and 3 for *M. bivittatus* and *M. mexicanus* the percentage of pods in the stages following blastokinesis (60% to 80% development or katatrepsis) is shown in the right half of the table.

TABLE 1. — FALL EMBRYOLOGICAL DEVELOPMENT IN *CAMNULA PELLUCIDA* EGGS

Location	[1]Population development in %			% Pre-blastokinesis pods (40 to 50% developed)		
MANITOBA						
Red River Valley	1941	1942	1943	1941	1942	1943
Arnaud	43	—	—	98	—	—
Greenridge	—	45	—	—	85	—
Rosser	41	38	—	100	78	—
Sperling	—	49	—	—	100	—
Domain	—	—	34	—	—	48
SASKATCHEWAN						
Central	1946	1947		1946	1947	
[2]R.M.375	—	42		—	71	
West Central						
R.M.287	—	49		—	97	
R.M.317	34	46		43	87	
Southwest						
R.M. 19	39	—		80	—	
R.M. 49	39	—		86	—	
Southeast						
R.M. 35	—	50		—	100	

[1]This is equivalent to the stage of mean development of the embryos in the collection. [2]R.M. — refers to Rural Municipalities which are numbered in Saskatchewan for mapping purposes.

TABLE 2. — FALL EMBRYOLOGICAL DEVELOPMENT IN *M. BIVITTATUS* EGGS.

Location	[1]Population development in %			% Post-blastokinesis pods (60 to 80% developed)		
MANITOBA						
Red River Valley	1941	1942	1943	1941	1942	1943
Arnaud	67	68	47	80	76	33
Ste. Elizabeth	—	—	56	—	—	58
Rosser	77	74	—	79	85	—
Sperling	—	—	47	—	—	32
Oakville	—	48	—	—	48	—
Elie	55	—	—	56	—	—
Southwest						
Lyleton	36	27	24	22	2	3
Elva	—	—	30	—	—	8
SASKATCHEWAN						
West Central	1943	1944	1947	1943	1944	1947
[2]R.M.257	—	—	52	—	—	47
R.M.287	30	—	—	3	—	—
R.M.316	35	—	—	0	—	—
R.M.345	34	—	—	9	—	—
R.M.375	—	—	61	—	—	73
South Central						
R.M.105	—	—	51	—	—	31
Southwest						
R.M.137	—	31	—	—	17	—
Southeast						
R.M.35	—	—	72	—	—	86
ALBERTA	1943	1944		1943	1944	
Granum	76	—		90	—	
MacLeod	59	—		52	—	
Nobleford	—	66		—	76	

[1]This is equivalent to the stage of mean development of the embryos in the collection. [2]R.M. — refers to Rural Municipalities which are numbered in Saskatchewan for mapping purposes.

TABLE 3. – FALL EMBRYOLOGICAL DEVELOPMENT IN *M. MEXICANUS* EGGS

Location	[1]Population development in %			% Post-blastokinesis pods (60 to 80% developed)		
MANITOBA						
Southwest	1941	1942	1943	1941	1942	1943
Lyleton	35	23	40	27	3	8
Elva	–	–	29	–	–	0
SASKATCHEWAN						
Central	1942	1943	1947	1942	1943	1947
[2]R.M.222	3	–	–	0	–	–
R.M.252	8	–	–	0	–	–
R.M.283	13	–	–	0	–	–
West Central	1942	1943	1947		1943	1947
R.M.287	–	14	–		0	–
R.M.316	–	31	–		0	–
R.M.317	–	–	62		–	66
R.M.345	–	26	–		2	–
R.M.375	–	–	63		–	75
North Central	1942	1943	1947	1942	1943	1947
R.M.403	–	30	–	–	0	–
South Central	1944	1945	1947	1944	1945	1947
R.M.105	–	–	33	–	–	24
Southwest	1944	1945	1947	1944	1945	1947
R.M. 78	–	20	–	–	4	–
R.M.137	31	–	–	17	–	–
ALBERTA	1943	1944	1947	1943	1944	1947
Granum	43	–	–	30	–	–
MacLeod	54	–	–	63	–	–
Carmangay	61	–	–	66	–	–
Nobleford	–	66	–	–	76	–

[1]This is equivalent to the stage of mean development of the embryos in the collection.
[2]R.M. – refers to Rural Municipalities which are numbered in Saskatchewan for mapping purposes.

The data obtained for *Camnula* in the Red River Valley (table 1) show that the embryos of this species were less developed in the fall of 1943 than in either 1941 or 1942 while development was slightly less in 1942 than in 1941. In 1943, 52% of the embryos of this species did not reach the pre-blastokinesis (40%) stage of development, while in the other years recorded practically all of them reached this stage. No eggs of this species have been observed with embryos over 50% developed in the fall. *Camnula* evidently enters a very definite diapause in the fall at the 50% stage just before blastokinesis (60% stage), unless development is stopped by adverse weather conditions before this stage is reached. *M. differentialis* (Thom.) has been shown by Bodine (3) and Slifer (1) to enter diapause at the stage just before blastokinesis occurs. Similarly Birch (4) has shown that *Austroicetes cruciata* Sauss. enters diapause at this same stage.

The data (table 2) show that the embryological development of *M. bivittatus* may vary from 0 to 80% in the fall. Embryos of *M. bivittatus* do not have an obligatory diapause at the stage just before blastokinesis as is the case with *C. pellucida, M. differentialis* and *A. cruciata.* Some *M. bivittatus* eggs may enter a diapause at the 80% stage of development. The stage of development at which eggs of this species enter the winter is quite variable within a population, from one location to another, and from year to year. In some years most of the eggs of this species develop up to the 80% stage in which the embryo is almost completely formed. The percentage of highly developed eggs was much lower in southwestern Manitoba than in the Red River Valley in the fall of 1941, 1942 and 1943. The percentage of highly developed eggs decreased progressively from 1941 to 1943 in the Red River Valley and in 1943 was very little advanced over that found at Lyleton, in southwestern Manitoba. Similarly, the embryological development of *M. bivittatus* eggs in Alberta in 1943 and 1944 was

high as compared with that of the Saskatchewan collections in the same years.

The results shown in table 3 indicate that the embryological development of *M. mexicanus* is similar to that of *M. bivittatus*. Embryos were found in stages of development varying from mere embryonic discs (10% stage), to practically fully developed embryos (80% stage) in the fall. Some of the embryos of *M. mexicanus* appear to enter a diapause at the 80% stage of development as in the case of *M. bivittatus*. Very few of the *M. mexicanus* eggs collected in the fall have been observed in this advanced stage of development. In general the fall embryological development of *M. mexicanus* populations was lower than that of *M. bivittatus* although collections at Carmangay and Nobleford in 1943 and 1944 approach some of the higher percentages of development recorded for *M. bivittatus*. Differences in development were greater between locations than between years in the collections examined. The eggs in all collections of *M. mexicanus* examined were more variable in development than in the case of the other two species.

All the viable eggs within individual pods were found to be of the same general stage of development in the three species studied. Slight variation did occur in some pods. Slifer (1) reports similar results in the study of *M. differentialis* eggs from single pods.

SUMMARY AND CONCLUSIONS

Methods of storing, clearing and examining embryos of *M. bivittatus*, *M. mexicanus* and *C. pellucida* in situ in the eggs are described.

It is shown that grasshopper eggs of these species vary considerably in the stage of embryological development at which they enter the winter. This variation differs from year to year and from district to district.

Camnula embryos appear to enter diapause just before blastokinesis occurs (50% stage of development). They do not always reach this stage before development is stopped by winter temperatures. The embryological development of *Camnula* is similar to that reported for *Austroicetes cruciata* and diapause type *M. differentialis* eggs in that diapause occurs at the same early stage in development.

M. bivittatus and *M. mexicanus* embryos may reach a much more advanced stage of development in the fall than those of *Camnula*. Development in the eggs of these species may range from 0% development to 80% development in the fall and in many cases embryos of the different stages occur throughout the whole range of development in a collection of pods. Development varies over a wide range from year to year and from district to district. If a diapause occurs in the embryological development of these species it must occur at the 80% stage, when the embryo is almost completely developed. No eggs of these species have been found in developmental stages beyond the 80% stage in fall collections of eggs. The embryological development of *M. bivittatus* and *M. mexicanus* differs from that of *Camnula, Austroicetes* and *M. differentialis* in not having an obligatory diapause just before blastokinesis.

The stage of development of the embryos within a single pod is quite uniform in the three species studied.

Sufficient variation in fall embryological development occurs in different years and in different areas in the three species under study to require varying amounts of heat to complete their development. This may affect the date of spring hatching and the length of the hatching period.

ACKNOWLEDGMENTS

Acknowledgment is made to Dr. R. D. Bird, Officer-in-charge of the Dominion Entomological Laboratory, Brandon, Manitoba, for permission to

carry out the above project. The writer gratefully expresses his indebtedness to Messrs. D. S. Smith and W. R. Allen of the Brandon Laboratory for their assistance in planning the above work and discussion of the methods developed. Dr. L. C. Paul, Dominion Entomological Laboratory, Saskatoon, Saskatchewan; Mr. R. M. White, Dominion Entomological Laboratory, Lethbridge, Alberta and members of the Brandon Laboratory staff gave considerable assistance in the collection of material and this is hereby gratefully acknowledged.

LITERATURE CITED

1. Slifer, E. H. 1932. Insect development IV. External morphology of grasshopper embryos of known age and with a known temperature history. Jour. Morph., 53:1.
2. Steele, H. V. 1941. Some observations on the embryonic development of *Austroicetes cruciata* Sauss. (Acrididae) in the field. Trans. Roy. Soc. Sth. Aust., 65:329.
3. Bodine, J. H. 1932. Hibernation and diapause in certain Othoptera. III. Diapause – a theory of its mechanism. Physiol. Zool., 5:549.
4. Birch, L. C. 1942. The influence of temperature above the developmental zero on the development of the eggs of *Austroicetes cruciata* Sauss. (Orthoptera) Aust. Jour. Exp. Biol. and Med. Sci., 20:17.

BOOK NOTICE

CHEMICAL INSECT, ATTRACTANTS AND REPELLENTS, by Vincent G. Dethier. XV and 289 pages, 69 illustrations. The Blakiston Company, Philadelphia, Pa. and Toronto, Canada. Price $5.75.

Due in large measure to the impetus given to the study of insect control by the needs of the armed services many new chemicals effective in the control of insects were discovered. Many of these discoveries were the result of the trial and error method, necessitated to a large extent by existing conditions, with little attempt to correlate results with chemoreception or insect behaviour.

In his preface to the present volume, the author, who served with the Inter-Allied Malaria Control Commission, Gold Coast, B.W.A., and is now Professor of Zoology and Entomology at the Ohio State University, states that "This text represents a theoretical study"—an endeavour to give a better understanding of the chemical, physical and biological background involved in the use of attractants and repellents, —rather than a manual of insecticides. "The study is essentially of stimulation and response", not involving "a comprehensive treatment of chemoreception". The book, therefore, "represents an attempt to bridge the borderline between chemoreception and the broader aspects of behaviour based upon it". Thus this volume is primarily concerned with the relation of the senses of smell and taste in insects to their behaviour.

The introductory chapter is a brief historical resumé of the subject. Chapters 2 to 8 are in large part factual. Chapters 2 to 5 deal with attractants: The Nature of Chemical Attractants; Essential Oils, Resins, and Related Substances; Fermentation Products (Alcohols, Acids, Aldehydes, Esters, Carbinols); Protein and Fat Decomposition Products (Fatty Acids, Amines, Ammonia, Carbon Dioxide). Chapter 6 deals with Olfactometers and Threshold Concentrations, Chapter 7, with Baits and Traps, and Chapter 8, with Repellents. Chapter 9, Chemical Basis of Taste and Olfaction, and Chapter 10, Evolution and Feeding Preferences, are largely interpretative in character, with a much broader significance than the title of the volume implies.

A bibliography is included with each chapter. A 25-page index completes the text.

Coming at a time when so much factual information on insecticides has been published, this book, which exemplifies the author's ability to interpret facts, and evaluate pertinent literature, is a welcome addition to the 'Science' of Entomology. R. H. Ozburn.

SOME NEARCTIC SPECIES OF HYDRADEPHAGID WATER BEETLES, NEW AND OLD (Coleoptera)[1]

HUGH B. LEECH
California Academy of Sciences, San Francisco.

Haliplus stagninus[2] n. sp.

A medium sized non-maculate species, allied to and resembling *H. strigatus* Roberts but more robust; elytra vittate as a result of the blackened strial punctures. Elytra of the female shining.

Male: Length 3.30 to 3.45 mm.; width 1.65 to 1.80 mm. Dorsal surface fulvous; base of head often piceous; large punctures across base of pronotum not blackened, though appearing so at a hasty glance because of a pattern of muscle attachments seen through the clear integuments; elytra non-maculate except for a small subsutural spot on an aggregation of punctures near the apices; punctures of elytral striae 1 to 8 blackened and narrowly annulated, those of 8 and 9 immaculate except a few apically, suture blackened in at least apical half. Ventral surface fulvous, except first three abdominal sternites which are piceous or black.

Head with eyes widely separated; punctures progressively coarser towards the base. *Pronotum* punctate except for a slightly inflated discal area on each side of median line; area between the elongate basal plicae usually impressed; lateral marginal beads narrow, widest basally. *Elytra* with strial punctures slightly irregularly placed and spaced, usually almost touching in apical half of striae; interstrial punctures almost as large as those of striae, spaced far apart, except for those of subsutural series which are progressively smaller and closer together from base to apex. *Prosternum* and its process flat or slightly inflated, not channeled or margined, in profile slightly depressed just before it widens at the front coxae; punctation variable, but generally finer and sparser than in *H. strigatus*. Mid-metasternum with a distinct longitudinal impression just within the margin on each side, behind mesocoxae. Median lobe of *genitalia* almost L-shaped (fig. 1), sinuate at the heel in a ventral view; anterior protarsal *claws* of same length as their fellows, but thicker, wider, more nearly parallel-sided.

Female. Similar to the male except for primary and secondary sex characters. Length 2.95 to 3.55 mm.; width 1.50 to 1.85 mm. Elytra shining, not at all alutaceous.

Holotype male and *allotype* female, KAMLOOPS, BRITISH COLUMBIA, I. VIII. 1937 (Geo. J. Spencer, collector). No. 5776 in the Canadian National Collection, Ottawa.

Paratypes: 10 males, 19 females, same data as types; 2 males, 3 females, small pond on west side of road, two miles south of Clinton, B.C., 11.X.43 (Hugh B. Leech and C. V. Morgan); 2 males, 1 female, Vernon, B.C., 18.IX.1937, pond near Johnson's, Old Kelowna Road (Hugh Leech); 1 female, same data, 10.X.1937; 1 female, Vernon, B.C., 8. VIII. 1939 (Hugh Leech); 2 females, Savona, B.C., roadside pond on highway to Kamloops (Hugh Leech); 1 male, Turtle Mts., NORTH DAKOTA, VIII.3.1920 (collection No. 110, T. H. Hubbell).

Paratypes will be distributed to the following institutions and persons: the British Museum, U.S. National Museum, California Academy of Sciences, University of British Columbia, Drs. F. Guignot, F. N. Young, Messrs. J. B. Wallis, H. P. Chandler, and G. Stace Smith.

Also studied: 12 males, 17 females, Vernon, B.C., 23.III.41, pond near Gartrell's mine (Hugh B. Leech). A single female taken in a pond at

[1]Contribution No. 2549, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

[2]From the Latin *stagnum*, a pool or pond: with reference to the habitat.

Mammoth, Mono Co., Calif., 21.IX.45. (G. P.Mackenzie) may be this species, but males are needed to confirm the identification.

In Wallis' key (1933. Revision of the North American species, (north of Mexico), of the genus Haliplus, Latreille. Roy. Canad. Institute, Trans. 19 (1):1-76, 37 text figs.), *stagninus* runs to *strigatus* Roberts, with which species it has been confused in collections. *H. stagninus* is larger and more robust (average length 3.4 mm.; of *strigatus* 3.0 mm.); the median lobe of the male genitalia is definitive, and the elytra of the female are shining, not alutaceous. From *robertsi* Zimmermann, the only other species with which it is likely to be confused, the larger size, long pronotal plicae, closely set and well blackened strial punctures and distinctive aedeagus will separate it.

Habitat. All examples of *stagninus* of which I have collecting knowledge have been found in ponds; some of the ponds are permanent, others become stagnant and finally dry up in summer. *H. strigatus* is usually equally common in the same waters.

Haliplus leechi carteri n. subsp.

?*Haliplus pantherinus* Mannerheim. 1852, Soc. Imp. Nat. Moscou, Bul. 25 (2): 302-303. (Not *Haliplus pantherinus* Aubé, 1838).

In June 1944 Mr. Norman M. Carter sent two pairs of a strongly maculate *Haliplus* sp. from Prince Rupert, on the northern coast of British Columbia. In September he obtained two males which are even darker.

In Wallis' key to the Nearctic species they trace to *leechi* Wallis, but are readily distinguished by their maculation. Four of the paratypes of *leechi* were from Terrace, which is slightly north and about 85 miles east of Prince Rupert, but they were not especially dark.

The new subspecies *carteri* differs from typical *leechi* (Vancouver paratypes) as follows: elytra strongly marked with piceous and black, the dark areas on each elytron including a small spot at the bases of striae 2 to 6, a blotch joining striae 5 and 6 at basal quarter, one across striae 2, 3, and 4 just before the middle, an irregular band just behind the middle from striae 1 to 8, a similar one, less well marked, in the apical quarter, and an apical spot. In some specimens these areas coalesce and the whole discal region from the basal quarter to the apical quarter is an irregular dark blotch. The prosternal process is narrower and more nearly parallel-sided in the apical half, but some variation is shown in the type series.

Holotype male, and *allotype* female, PRINCE RUPERT, BRITISH COLUMBIA, 8.VII.44 (N. Carter). No. 5777 in the Canadian National Collection.

Paratypes: 1 male, 1 female, same data as types; two males, 17.IX.44 (N. M. Carter). One paratype will be sent to Mr J. B. Wallis, one to Mr. H. P. Chandler.

Hydroporus laetus[3] n. sp.

A small, narrow, fasciate species (figs. 10 and 11), resembling and most closely allied to *pulcher* LeConte and *cocheconis* Fall. Known from Vinton Co., Ohio.

Male. Length 3.15 to 3.30 mm.; width 2.0 to 2.15 mm. Form elongate, widest at middle of length, elytra nearly parallel-sided in basal half. Head rufous, antennae rufous, segments 8 to 10 usually infuscate, 11 black except at base. Pronotum darkest posteriorly and anteriorly, the lateral marginal bead and a narrow adjacent area rufous. Elytra piceous or black, with pale yellow markings; in dark examples the pale areas are: an irregular basal spot from humerus to about half way to suture, broad later-

[3]From the Latin *laetus*, gay or pleasing; referring to the prettily maculate elytra.

ally, narrow and directed posteriorly on the discal side, and a lunule between this and the suture; a small sublateral postmedian spot; and a larger preapical spot; in well marked specimens the basal pale area may extend unbroken almost to the suture, the postmedian spot more than half way to the suture, and the preapical spot further forward. Mouthparts, epipleura, and femora rufous, tibiae and tarsi a little darker; metasternum, metacoxal plates and abdominal sternites rufous, usually piceous laterally, sometimes largely dark.

Head finely punctate, the surface microreticulate. Pronotum a little more coarsely punctate than head, the surface finely alutaceous; lateral margins rather broad and flat, as in *pulcher*. Discal elytral punctation like that of pronotum, but sparser, almost disappearing laterally and apically. *Prosternum* without antecoxal setae; basal half of process with a notch and transverse file, apical half narrow, margined laterally and with a smooth longitudinal carina. Sides of metasternum coarsely punctate, the metacoxal plates slightly less so. Abdominal sternites very finely punctate, except the first two which may be nearly as coarsely punctate as the metacoxal plates. *Pro-* and *mesotarsi* narrow, not appreciably wider than in the female; protarsal claws of equal length, the inner one straighter than its fellow, more abruptly bent at base, the lower margin slightly sinuate. *Aedeagus* bifid apically, the tips slightly hooked in profile (fig. 2).

Female. Length 3.30 to 3.55 mm.; width 2.20 to 2.30 mm. Very similar to the male, but larger and sometimes with more extensive pale markings on the elytra.

Holotype male, and *allotype* female, from a stream adjacent to LAKE HOPE, VINTON CO., OHIO, 30.VIII.1945 (W. C. Stehr, collector). Nos. 5940 and 5941 in the California Academy of Sciences.

Paratypes: 13 males, 18 females, all with the same data as the type; 4 females, same locality and collector, 26.IV.46. Paratypes will be distributted to: The British Museum, United States National Museum, Canadian National Collection, Ohio State University, Drs. F. N. Young, F. Guignot, Messrs. J. B. Wallis, H. P. Chandler, and C. A. Frost.

Variations in markings. The holotype and 7 male paratypes have the elytra relatively dark, i.e. the basal pale fascia is somewhat broken or includes piceous areas, and the postmedian fascia is confined to a lateral spot. In 6 males the postmedian extends at least halfway to the suture, and there is a pale spot between it and the suture (fig. 10); in only one of these males is the basal fascia free of piceous streaks or spots. The allotype and 11 female paratypes resemble the males, but 7 females have the basal, postmedian, and preapical fasciae unbroken and extending inward almost to the suture (fig. 11); they could better be described as yellow with black fasciae, than vice versa. In the most extreme specimen the pale fasciae are joined along the lateral margin, and the postmedian and preapical almost join at their sutural extremities.

Habitat. In a letter dated September 16, 1945, Dr. Stehr described the type locality: "..... were taken under about a square yard of leaves and stones in the bottom of a dried-up pool in a small temporary stream. They were all about half burrowed into damp mud under the cover. The pool itself was about 100 ft. from the shore of Lake Hope." On May 1, 1946, in reporting on the finding of 4 more specimens, he wrote: "They were taken in the same pool which at this time was full of water as the intermittent stream was carrying run-off from recent rains. We swept the lake itself in the area nearby and in many parts but found none of this *Hydroporus*."

Hydroporus laetus runs in Fall's key (1923. Revision of the North American species of *Hydroporus,* p. 8-9) to couplet 7; in this, most specimens will fit the first choice better. They may be distinguished from *pulcher* Leconte by the coarsely punctate sides of the mesosternum and metacoxal plates, by their smaller size, more parallel-sided form, piceous pronotum narrower anterior tip to the metasternum, and shape of the male genitalia (figs. 2 and 4). From *cocheconis* Fall they may be separated by their more elongate parallel-sided form, piceous pronotum, finer dorsal punctation, and differently shaped male genitalia.

Some *laetus* are rather dark beneath and might be put in the second part of couplet 7. They are at once distinguished from *vitiosus* LeConte by their piceous pronotum, more coarsely punctate metacoxal plates, obviously fasciate elytra with the suture black, and distinctive male genitalia.

As a matter of fact, though specimens of *vitiosus* run correctly in the key, that species is phylogenetically out of place in Fall's revision. It has the median lobe of the male genitalia simple, and sinuately curved in a dorsal view as, for instance, in most species of *Hygrotus.* In *pulcher, cocheconus wickhami* Zaitzev, *ohionus* Fall, and *oppositus* Say the median lobe is straight in a dorsal or ventral view, but always bifid apically (figs. 2-5). These matters require further study, for Brinck has recently[4] designated *Hydroporus concinnus* LeConte, 1855 (*concinnus* LeConte nec *concinnus* Stephens, 1835, is now called *wickhami* Zaitzev) as the type of the subgenus *Heterosternuta* Strand. The subgeneric name was proposed by Strand (1935 Revision von Gattungsnamen palaearktischer Coleoptera. Folia Zoologica et Hydrobiologica 7 (2): 282-299. *Heterosternuta,* p. 291) to replace *Heterosternus* Zimmermann, 1919, nec Dupont, 1832, nec Kirsch, 1869. Zimmermann originally included one Palearctic species, *picicornis* J. Sahlberg, and a number of Nearctic forms; of the latter he remarked that some he had not seen, so the list would prove to be neither complete nor accurate. Later Guignot removed *picicornis* to his subgenus *Neoporus.* These and other proposed subgenera of *Hydroporus* have been hotly discussed by several European writers, notably the late G. Falkenström and F. Balfour-Browne.

Zimmermann's figure (1919. Arch. f. Naturg. (1917), 83 (12): 155, fig. 10) of the metacoxal process of *wickhami* Zaitzev (*concinnus* LeConte) is not entirely accurate. Certainly the species he included in his subgenus are not all closely allied, and although most of the species of the *vilis* group have the aedeagus bifid apically, but not of the *pulcher* type, they are not phylogenetically close to the *pulcher* group, as I have pointed out (1941. Pan-Pacific Ent. 17 (3): 132).

Hydroporus niger Say

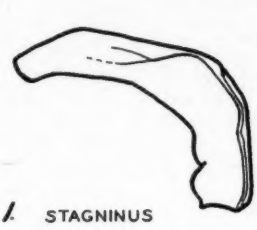
Hydroporus niger Say, 1823, Amer. Philos. Soc., Trans. (N.S.) 2: 102; Fall, 1923, Revis. N. Amer. spp. Hydroporus and Agaporus pp. 63, 75, 76.

Hydroporus modestus Aubé, 1838, Species gén. des Hydrocanthares et Gyriniens, p. 576.

Hydroporus latifrons Sharp, 1882, Roy. Dublin Soc., Sci. Trans. (2) 2:478. (Fide J. Balfour-Browne). *New synonymy.*

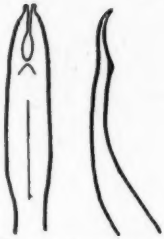
Upon examining a series of *H. niger* Say, from Athens, Ohio, intermixed examples of an allied species which traced to *latifrons* Sharp in Fall's key (1923:63) were recognized. They seemed to fit Sharp's description, so in high glee at finding the long lost *latifrons* I sent specimens to Mr. J. Balfour-Browne, to be compared with the type in the British Museum.

[4]1943. Nomenklatorische und systematische Studien über Dytisciden. Kungl. Fysiografiska Sällskapets Förhandingar 13 (13): 1-13 (Genotype designations on p. 6).

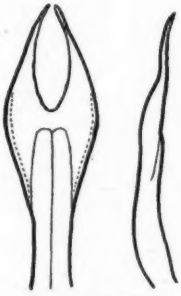


1. STAGNINUS

2. LAETUS



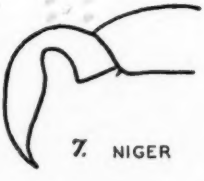
3. COCHECONIS



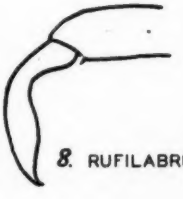
4. PULCHER

5. WICKHAMI

6. RUFILABRIS

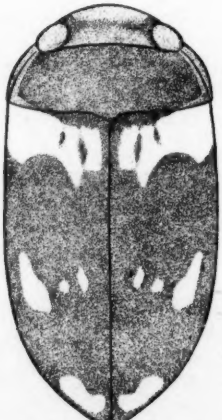


7. NIGER

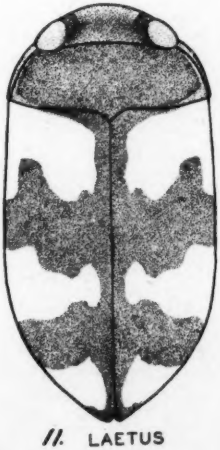


8. RUFILABRIS

9. NIGER



10. LAETUS



11. LAETUS

Figs. 2, 3, 4, 5, 6, 9, drawn to the same scale. Figs. 7 and 8 to the same scale, but not to the scale of the other drawings.

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1. La

He reported (letter of March 26, 1946) that "..... *Hydroporus latifrons* Sharp is a simple synonym of *H. niger* Say. I dissected the unique type of the former some years ago and realized that it did not represent a good species..... It should be made clear that the *niger* Say of Sharp's Monograph is not Say's species but is *signatus* Mann,.. as is, undoubtedly, *inornatus* Sharp..... Sharp's 'type' of his *niger* and the holotype of *inornatus* are both labelled in Sharp's writing 'sent by LeConte as *H. niger*', so it seems that LeConte had both species mixed in his collection. The characters given by Sharp to distinguish *inornatus* and his concept of *niger* are seen to be illusory when the types are properly clean."

It is probable that Sharp was not entirely satisfied with his identification of Say's species, for although he describes it in the body of his Monograph (species No. 622, p. 478), he also quotes the original description in full in the "Appendix of descriptions not identified with species known to the author" (No. 1404, p. 803).

Hydroporus rufilabris Sharp

Hydroporus rufilabris Sharp, 1882, Roy. Dublin Soc., Sci. Trans. (2) 2:479; Fall, 1923, Revis. N. Amer. spp. Hydroporus and Agaporus, pp. 63, 77, 78.

The distinctive species which seemed to trace to *latifrons* (see above) I had planned to describe and name, but fortunately Mr. Balfour-Browne compared a specimen with the type of *rufilabris* Sharp, 1882, which it proved to be.

H. rufilabris was based on a pair collected in Texas by Belfrage. In 1923 Fall had seen only the female cotype and a pair in the LeConte collection. The species has not been reported since, so the following distributional records are of interest: OHIO, Athens, November 8, 1945 (W. C. Stehr). VIRGINIA, Mountain Lake, in a temporary pond, August 14, 1941 (A. C. Cole). TENNESSEE, Blue Grass near Knoxville, October 30 and 31, 1940 (G. Keener); Blue Grass, in a sluggish stream, November 4, 1940 (A. C. Cole); Knoxville, April 17, 1940 (A. C. Cole); pond along State Highway 106, at Little Harpeth River, Williamson Co., May 24, 1945 (M. Wright); Radnor Lake, Davidson Co., May 12, 1945 (M. Wright). SOUTH CARO-106, at little Harpeth River, Williamson Co., May 24, 1945 (M. Wright); LINA, Gable, November 3, 1944 (O. L. Cartwright). Mr. Balfour-Browne reports a pair from NORTH CAROLINA, Natahala Forest.

H. rufilabris is most likely to be confused with *niger,* and with *somnus* Fall. My specimens vary in size: females from 3.90 to 4.40 mm., males from 4.15 to 4.75 mm. In addition the anterior protarsal claws of the male vary in shape and slightly in length. Fall's key calls for "Claws of front tarsus of male equal in length, the anterior one just perceptibly stouter, not dilated medially, the inner and outer edges parallel up to the abruptly obliquely acuminate tip." This applies excellently to *somnus,* a Wisconsin species, in which the claws are as long as the segment which bears them, and which also has the median lobe of the aedeagus shaped almost as in *niger* (fig. 9). But in *rufiflabris* the claws are only two-thirds as long as the segment bearing them, and the anterior ones are often dilated internally (fig. 8).

The following couplet will separate *niger* from *rufilabris.*

1. Larger species, 4.25 to 5.0 mm. long. Male: pro- and mesotarsi moderately dilated, much wider than in the female; anterior protarsal claws with a basal enlargement, incrassate, sinuate along lower edge (fig. 7), and shorter than their fellows which are slender and slightly sinuate; median lobe of genitalia rather narrow, pointed, with a sharp longi-

tudinal carina (fig. 9). Female: elytra dull, very finely punctate. Quebec, Maine, West Virginia, westward to Kansas ..... *niger*

—. Smaller species, 3.90 to 4.75 mm. Male: pro- and mesotarsi narrow, barely wider than in female; anterior protarsal claws without basal enlargement, parallel-sided in basal half, thence usually slightly widened on the lower margin, thence usually oblique to the sharp tip (fig. 8), their fellows similar but slightly narrower; median lobe of genitalia almost spatulate, blunt apically except for a median nubbin, and with a rounded longitudinal carina (fig. 6). Ohio, Virginia, Tennessee, South Carolina, Texas ..... *rufilabris*

Löding has recorded *niger* from Mobile Co., Alabama (1945. Catalogue of the beetles of Alabama. Geological Survey of Ala., Monograph 11: 1-172. University, Ala.), but distributional records indicate that *rufilabris* is more likely to occur there.

In the past I have confused small specimens of *rufilabris* with large examples of *signatus* Mannerheim. They are readily separated, however. Females of *signatus* have the elytra dull and very finely punctate, not shining and like the male as in *rufilabris*, while males of *signatus* have the pro- and mesotarsi much wider than in the female, with the protarsal claws narrow and slightly hooked apically, and the median lobe of the genitalia intermediate in form between *niger* and *rufilabris* but not carinate except near the tip. It is probable that *signatus* belongs near *niger*, phylogenetically, rather than where it is placed in Fall's revision.

Habitat. The only habitat datum available on *rufilabris* refers to one of the Tennessee examples and is quoted, with permission, from Professor Mike Wright's article "A description of the nymph of *Sympetrum ambiguum* (Rambur), with habitat notes." (Tenn. Acad. Sci., Jour. 21 (1):135-138).

"The pond in which these nymphs were found is located along State Highway 106 at Little Harpeth River, about 9 miles south of Nashville, Tennessee. The pond lies in a low area between the highway on the west, an old highway bed on the east, Little Harpeth River on the north and a private road on the south. It is at present separated by about 200 feet from the river, but, from all indications, the pond was connected to it during the high water period of Little Harpeth River. At the time of collecting the water was between one and three feet in depth, but was slowly drying up. The bottom was mucky, but so covered with grass and weed roots as to make walking easy. Grass, weeds, shrubs and small willow trees were abundant at the edge and in the water. There were no large trees or other vegetation giving shade to the pond. Algae was abundant, especially along the edges where it occurred in heavy pads. The drying up of the pond was evidenced by the large areas of exposed algae pads and debris. A water analysis made by Dr. C.S. Shoup, Vanderbilt University, showed a pH of 8.3, total carbonates (methyl orange alkalinity) of 132 ppm, and a water temperature of 84 degrees F."

Acknowledgments. I am indebted to Mr. Ben Sugden for drawing figures 10 and 11, and to Mr. J. Balfour-Browne for comparing specimens with the David Sharp types.

EXPLANATION OF PLATE

Fig. 1. *Haliplus stagninus* n. sp., lateral view of aedeagus.
Fig. 2. *Hydroporus laetus* n. sp., apical part of aedeagus; view of dorsal (concave) surface at left, same in profile at right.
Figs. 3, 4 and 5, same of *Hydroporus cocheconis* Fall, *pulcher* LeConte and *wickhami* Zaitzev.
Fig. 6. *Hydroporus rufilabris* Sharp, apical part of aedeagus, dorsal view.
Figs. 7 and 8. Anterior protarsal claws of *Hydroporus niger* Say and *rufilabris*.
Fig. 9. *Hydroporus niger*, apical part of aedeagus, dorsal view.
Figs. 10 and 11. *Hydroporus laetus*, to show variations in maculation.

A REVIEW OF THE RHYACOPHILIDAE (TRICHOPTERA)

BY D. G. DENNING
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Recent examination of a large number of Rhyacophilidae has resulted in the establishment of some very interesting distributional records as well as the recognition of several new species. New species, descriptions of hitherto unassociated females or little known species, and new distributional records in the *Rhyacophila, Glossosoma, Anagapetus, Agapetus, and Atopsyche* are discussed in this paper. I would like to take this opportunity to thank Dr. L. J. Milne of the University of Vermont for the generous loan of his *Rhyacophila* holotypes, fourteen of which are figured and briefly described herein. Material from the University of Massachusetts is designated as (Mass.), from the University of Minnesota as (Minn.), from the American Museum of Natural History as (AMNH), from the North Carolina Department of Agriculture as (NC) and from the California Academy of Sciences as (Cal.). Unless designated otherwise types are in the writer's collection at the University of Wyoming.

At present there are 68 species of *Rhyacophila* recorded from Canada and the United States. The distribution of all of these species is poorly known, a majority being known only from the holotype or the type lot.

Rhyacophila acropedes Banks

Ross has recorded a male from Labrador; until then it was considered a western species. As such, then, the following records from New England are quite significant.

New Hampshire: White Mountains, July 31, 1944, (J. F. Hanson), 4 males, 2 females, (Mass.); Crystal Cascade, White Mountains, elevation 2100 feet, July 31, 1944 (J. F. Hanson), 1 male, (Mass.); Huntington Ravine, Mt. Washington, elevation 3000-3400 feet, August 4, 1944, (J. F. Hanson), 6 males, 1 female, (Mass.). Wyoming: Snowy Range Mountains, Albany County, August 3, 1947, (D. G. Denning), 10 males, 3 females. Colorado: Cameron Pass, August 18, 1947, (D. G. Denning), 1 male, 2 females.

The writer observed that in handling the living males and females a strong offensive odor was emitted.

Rhyacophila angelita Banks

Described originally from Pasadena, California, this species is probably widely distributed throughout the west. Genitalia as in fig. 1.

Colorado: Loveland Pass, August 22, 1940, elevation 5000 feet, (C. E. Mickel), 1 male, (Minn.); Cameron Pass, August 20, 1940, at light, (H. E. Milleron), 1 female, (Minn.). Wyoming: The writer and R. E. Pfadt have collected this species at numerous localities, generally at high elevations and found it fairly abundant along fast mountain streams from August 23 to September 25. British Columbia: Cowichan River, Cowichan Lake. November 24, 1939, (C. P. Idyll), 3 males, 8 females, (Minn.).

Rhyacophila arnaudi n. sp.

The long bifid projection of the ninth tergite will readily differentiate this species from other described species.

Male.—Length 10 mm. Wings medium brown with a dark irrorate pattern. Legs yellowish, dorsal half of middle tibia between spurs dark brown, as well as most of tarsus. General structure typical for genus.

Genitalia as in fig. 2. Sternite of ninth segment narrow, gradually widened dorsally; tergum projected caudad slightly beyond tenth tergite as a broadly furcate declivous structure; deeply excavated from ventral aspect, convex dorsally; apical prongs acute, directed caudo-ventrad; setation sparse. Tenth tergite projected caudad to apical segment of clasper, gradually direc-

ted ventrad, a short U-shaped incision apically when seen from dorsal aspect; dorsal angle produced into a sub-acute triangular projection; ventral angle widely circular and flared slightly laterad, mesal margins serrate. Basal segment of clasper approximately one-third longer than apical segment, somewhat parallel-sided; dorsal angle of apical segment but slightly produced, ventral margin about three times as long as dorsal and directed ventrocaudad, apex blunt; mesal surface with dense short setae. Sheath of aedeagus a yellowish translucent plate which tapers suddenly to an apically upturned rod-like structure; ventrad to above plate is a pair of translucent, slender apically convergent rod-like structures, apex furcate from lateral view, acute from dorsal or ventral view; apices do not quite reach apex of above mentioned plate; both structures extend a short distance beyond apex of claspers.

Holotype. Male.—Camp Abbot, Oregon, Deschutes County, April 2, 1944, (Paul H. Arnaud).

I take pleasure in naming this species in honor of the collector, Mr. Paul H. Arnaud.

Rhyacophila atrata Banks

Originally described from North Carolina this small species is herein recorded from New England.

New Hampshire: White Mountains, July 31, 1944, elevation 2100-5000 feet, (J. F. Hanson), 4 males, 3 females, (Mass.); Mt. Washington, August 4, 1944, (J. F. Hanson), 4 males, 4 females, (Mass.). Massachusetts: Pelham, Amethyst Brook, June 19, 1938, (J. F. Hanson), 1 male, (Mass.),

Rhyacophila banksi Ross

This species was recently described from New Hampshire.

New Hampshire: Huntington Ravine, White Mountains, July 4, 1944, (J. F. Hanson), 1 male, (Mass.); Tuckerman's Ravine Trail, White Mountains, July 31, 1944, elevation 3000-5000 feet, (J. F. Hanson), 1 male, (Mass.). Vermont: Lake Willoughby, June 17-29, 1945, elevation 1400 feet, (C. P. Alexander), 4 males, 2 females, (Mass.).

Rhyacophila basalis Banks

This species was previously known only from California and Utah.

Wyoming: Evanston, September 23, 1947, (R. E. Pfadt), 1 male.

Rhyacophila bifila Banks

This species was originally described from British Columbia. It is closely related to *coloradensis* Banks, and the marked similarity of the male and female genitalia to *Coloradensis* is at once apparent, fig. 3.

California: Middle Fork, Stanislaus River, Tuokenine County, August 27, 1947, (P. H. Arnaud), 9 males, 2 females.

Rhyacophila brunnea Banks

Originally described from New Mexico this species is now known to occur as far north as British Columbia.

Wyoming: N. Platte River, 9 miles N. of State Line, September 7, 1947, (D. G. Denning), 1 male. British Columbia: Cowichan River, Cowichan Lake, June, 1939, (C. P. Idyll), 70 males, 29 females, (Minn.). California: Happy Isles, June 30, 1936, (H. J. Rayner), 1 male; Yosemite Valley, July 5, 1937, (E. H. Nast), 1 male, (Cal.).

Rhyacophila carolina Banks

Massachusetts: Pelham, June 4, 1938, (J. F. Hanson), 2 males, 2 females. New Hampshire: Mt. Washington, July 4, 1944, (J. F. Hanson) 1 male.

Rhyacophila carpenteri Milne

New Hampshire: Tuckerman's Ravine, White Mountains, July 31, 1944, (J. F. Hanson), 1 male, (Mass.); Huntington Ravine, Mt. Washington, August 4, 1944, (J. F. Hanson), 2 males, (Mass.).

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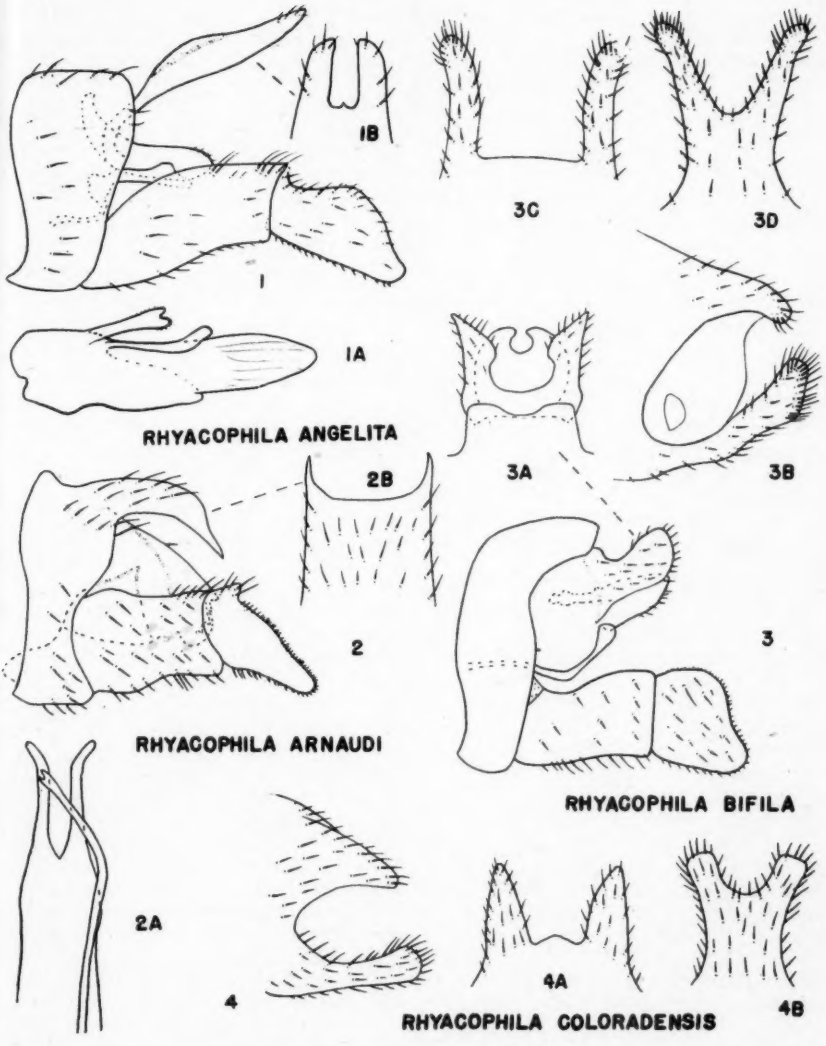


EXPLANATION OF PLATE I

Fig. 1. *Ryacophila angelita,* male genitalia, lateral aspect; 1A, aedeagus; 1B, tenth tergite, dorsal aspect.

Fig. 2. *Rhyacophila arnaudi,* male genitalia, lateral aspect; 2A, ventral sheath of aedeagus; 2B, tenth tergite, dorsal aspect.

Fig. 3. *Rhyacophila bifila,* male genitalia, lateral aspect; 3A, tenth tergite, dorsal aspect; 3B, female genitalia, lateral aspect; 3C, female genitalia, dorsal aspect; 3D, female genitalia, ventral aspect.

Fig. 4. *Ryacophila coloradensis,* female genitalia, lateral aspect; 4A, female genitalia, dorsal aspect; 4B, female genitalia, ventral aspect.

Rhyacophila coloradensis Banks

This species is widely distributed throughout Wyoming and northern Colorado. It is probably the most abundant *Rhyacophila* in Wyoming; the majority were taken from August 9 to September 7. Female genitalia shown in fig. 4; some variation in the emargination of the genitalia is found.

Rhyacophila fuscula (Walker)

Widely distributed in the East this species has not previously been recorded as far west as Minnesota.

Massachusetts; Pelham, Amethyst Brook, June 19, 1938, (J. F. Hanson), 1 male, 1 female, (Mass.). North Carolina: Avery County, June, 1936, (R. W. Leiby), (NC). Minnesota: Two Island River, Cook County, August 5, 1939, (R. H. Daggy), 1 male, (Minn.).

Rhyacophila glaberrima Ulmer

Known from a large number of records from New Hampshire, collected from July 31, to August 15. Virginia: Washington, August 27, 1933, (J. H .Roberts), 1 male, (Minn.).

Rhyacophila hardeni, n, sp.

This species belongs to the *carolina* group, and is probably closest to *fenestra* Ross. It can easily be separated from that and other described species by the complicated tenth tergite, the shape of the apical segment of the clasper, and the lateral arm and ventral sheath of the aedeagus.

Length 9 mm. Head and body light brown, legs light yellow. Fore and hind wings uniformly dark brown; the forewings with the following white markings: covering r-m, at fork of M, and a small spot at junction of A and margin of wing.

Genitalia as in fig. 5. Ninth segment with ventral portion narrower than dorsal portion. Tenth tergite, viewed dorsally fig. 5A, with a deep truncate excavation down the meson dividing the apical portion into a pair of triangular lobes; viewed laterally the dorsal margin convex and lateral lobes acute; floor of above trough extends ventrad as a sheath which encloses the next structure, an elongate apically rounded process which is capable of a ventro-dorsad movement, this structure when viewed dorsally, fig. 5, is apically emarginate; the ventral floor of the tenth segment is lightly sclerotized, extends caudad beyond remainder as an apically flared and triangularly emarginate structure. Claspers with basal segment short, broad, ventral margin strongly angled; apical segment with a broad dorsal lobe, apical margin somewhat arcuate, ventral lobe tapering caudo-ventrad; mesal face thickened with a heavy pad of dense short setae as indicated in fig. 5. Lateral arms of aedeagus semi-membranous, enlarged apically, viewed from dorsal aspect apex abruptly turned laterad; apex covered with a dense group of closely appressed dark brown spines, considerable amount of setae over remainder, fig. 5D; carinate process very similar to *fenestra*, fig. 5C; ventral sheath lightly sclerotized, lateral portion flared dorsad, from ventral view, fig. 5B, lateral lobes extend caudad a considerable distance beyond apical emargination.

Holotype. Male – Dalton, Georgia, June 2, 1947, (P. H. Harden).

It is with pleasure that I name this species in honor of Dr. P. H. Harden who collected not only this but many other interesting Trichoptera,

Rhyacophila harmstoni Ross

This recently described species was previously known only from Utah. Colorado: Cameron Pass, August 18, 1947, (D. G. Denning), 3 males.

Rhyacophila hyalinata Banks

Little is known regarding the occurrence of this interesting species, Colorado: Poudre River, near Cameron Pass, August 19, 1947, (D. G.

Denning), 1 male, 2 females. Wyoming: Woods Landing, Albany County, September 1, 1947, elevation 7500 feet, (D. G. Denning), 1 male.

Rhyacophila mycta Ross

North Carolina: Mt. Mitchell, June 17, 1924, above 4000 feet, (F. Sherman), 1 male, (Marked paratype of *carpenteri.*). (NC).

Rhyacophila norcuta Ross

Washington: Mt. Adams, June 30, 1925, (E. C. Van Dyke), 1 male, (Cal.). Oregon: Newport, June 8, 1925, (E. C. Van Dyke), 1 male, (Cal.). California: Santa Cruz, June 2, 1919, (E. P. Van Duzee), 1 male, 1 female, (Cal.).

Rhyacophila oreta Ross

This species was previously known from Utah and Oregon.

California: Woodacre, Marin County, September 21, 1930, (E. P. Van Duzee), 1 male, (Cal.).

Rhyacophila pellisa Ross

This species has not been recorded in the literature since it was originally described from Colorado.

Colorado: Poudre River, 15 miles east of Cameron Pass, August 19, 1947, (D. G. Denning), 2 males, 1 female; Cameron Pass, August 18-19, 1947, (D. G. Denning), 5 males, 2 females; Rocky Mt. National Park, August 9, 1947, (D. G. Denning), 3 males, 2 females:. Wyoming: Snowy Range Mountains, near Centennial, August 3, 1947, (D. G. Denning), 13 males.

Rhyacophila rotunda Banks

Very little is known of the occurrence of this species, originally described from Nevada.

Utah: Zion Nat. Park, June 21, 1942, elevation 4500 feet, (C. P. Alexander), 2 males, (Mass.). California: Cascada, Fresno County, July 29, 1919, altitude 5000 feet, (E. P. Van Duzee), (Cal.).

Rhyacophila torva Hagen

This species is quite common in the East. It has not previously been recorded from the central part of the United States.

Massachusetts: Pelham, June 14, 1938, (J. F. Hanson), 4 males, (Mass.). New Hampshire: White Mountains, June 4, 1940, elevation 4650 feet, (J. F. Hanson), 1 male, 2 females, (Mass.). Tennessee: Trillium Gap Trail, Mt. Lecante, April 12, 1941, elevation 3900 feet, (H. S. Schenker), 1 male, (Mass.). Virginia: Washington, August 27, 1933, (J. H. Roberts), 1 male, (Minn.).

Rhyacophila valuma Milne

Colorado: Aspen, July 24-27, 1919, elevation 8000 feet, (marked paratypes), (AMNH).

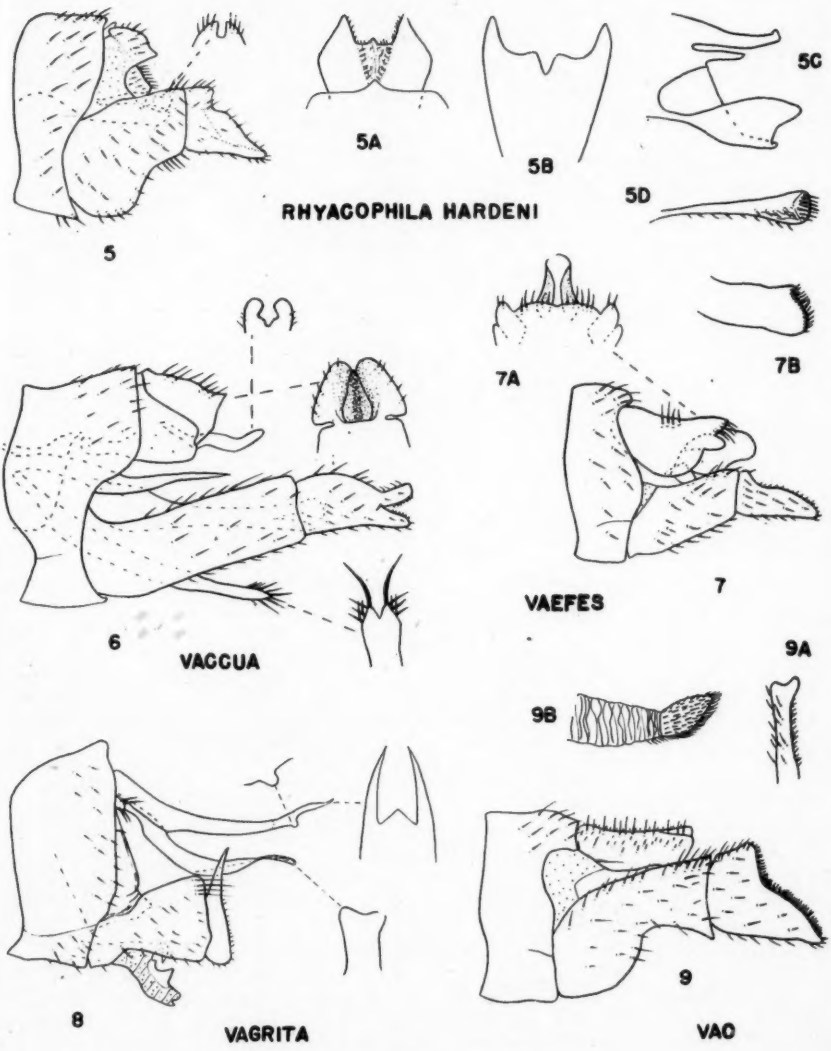
California: Lake Tahoe, June 23, 1925, (E. H. Nast), 1 male, (Cal.).

Rhyacophila verrula Milne

Previously known to occur in British Columbia, Alberta, Oregon, Washington, and Wyoming. Montana: Girds Creek, Ravalli County, October 5, 1935, (W. L. Jellison), 3 females, (Minn.). Alberta: Waterton, August 29, 1924, (E. R. Tinkham), 1 female, (Minn.).

Rhyacophila vaccua Milne

Holotype, male.. — Cultus Lake, B.C., August 25, 1934, (W. E. Ricker). Length 14 mm. Wings light brown with golden irroration. This species can easily be recognized by its bifid claspers; flat tenth tergite with its deep mesal groove the entire length and the small flattened emarginate structure projecting caudad from the ventral portion of the tergite which



EXPLANATION OF PLATE II

Fig. 5. *Ryacophila hardeni,* male genitalia, lateral aspect; 5A, tenth tergite, dorsal aspect; 5B, ventral sheath of aedeagus, ventral aspect; 5C, carinate process and ventral sheath of aedeagus, lateral aspect; 5D, lateral arm of aedeagus, lateral aspect.

Fig. 6. *Rhyacophila vaccua,* male genitalia, lateral aspect; tenth tergite, dorsal aspect; apex of ventral process of aedeagus, dorsal aspect.

Fig. 7. *Rhyacophila vaefes,* male genitalia, lateral aspect; 7A, tenth tergite, dorsal aspect.

Fig. 8. *Rhyacophila vagrita,* male genitalia, lateral aspect.

Fig. 9. *Rhyacophila vao,* male genitalia, lateral aspect; 9A, left lateral half of tenth tergite, dorsal aspect; 9B, lateral arm of aedeagus.

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is capable of a dorso-ventrad movement. Dorsal sheath of aedeagus concave, apically acuminate; ventral plate with a short apical emargination, each lateral portion bearing a thick group of spines, fig. 6.

Rhyacophila vaefes Milne

Holotype, male. – Cultus Lake, B. C., August 25, 1934, (W. E. Ricker).

Oregon: Waldport Lincoln County, June 13, 1936, (E. C. Van Dyke), 1 male, 1 female, (Cal.); Williamette River, near Oakridge, June 27, 1948, (D. G. Denning), 1 male.

Length 9 mm. Wings light brown, appendages luteus. The distinctive tenth tergite and wide, flat lateral arms of the aedeagus will serve to differentiate this species, fig. 7.

Rhyacophila vagrita Milne

Holotype, male. – Cultus Lake, B. C., August 24, 1934, (W. E. Ricker).

Length 9 mm. Wings light brown, appendages slightly lighter in color. This species is radically different from any other described species. Tenth tergite divided at base into a flattened dorsal branch, apex divided into a pair of acute lateral branches and a ventral branch whose basal half is cylindrical, then widened into a convex plate which apically becomes flat and thin, apex slightly emarginate and asymmetrical. Apical segment of clasper very narrow, acute dorsally. Apex of aedeagus with a wide flat dorsal hook opposite a ventral acute process, fig. 8.

Rhyacophila vao Milne

Holotype, male. – Cultus Lake, B. C., July 8, 1934, (W. E. Ricker).

Alaska: Ft. Yukon, June 30, 1916, (J. A. Kusche), 2 males, 3 females, (Cal.).

Length 11 mm. Wings light brown, almost glabrous except stigma darker and covered with short yellowish setae. Tenth tergite long, narrow, approximately in the shape of a parallelogram, cleft into two closely appressed lateral halves. Lateral arm of aedeagus semi-membranous apex with dense mat of reddish-brown setae, fig. 9.

Rhyacophila vedra Milne

1938. Rhyacophila californica Ling, Pan-Pacific Ent., XIV, (2), p. 60. (New Synonymy).

Holotype, male. – Oak Creek, Corvalis, Oregon, June 2, 1934, (Eldon Ball).

California: Berkeley Hills, Alameda County, April 13, 1936, (H. J. Rayner), 1 male, (Cal.); Santa Cruz, June 2, 1919, (E. P. Van Duzee), 1 male, (Cal.); Alpine Lake, Marin County, October 6, 1935, (H. J. Rayner), 1 male, (Cal.); Pottera Valley, Madona County, May 1, 1929, (E. H. Nast), 1 male, (Cal.).

Length 12 mm. Wings light brown, lightly irrorate; appendages yellowish. The extreme elongation of the ninth tergite and the short rounded tenth tergite will distinguish this species. Aedeagus with a carinate structure and a ventral tube from whose apex arises a V-shaped group of spines and in addition a ventrad directed group of spines cephalad from apex, fig. 10.

Rhyacophila vemna Milne

Holotype, male. – White River, Mt. Ranier, Washington, May 12, 1934, (W. E. Ricker).

Washington: Paradise Valley, Ranier Nat. Park, July 18, 1936, (E. C. Van Dyke), 1 male, (Cal.); same except July 15, 1920, 1 male, (Cal.).

Length 17 mm. Wings yellowish, lightly irrorate, stigma brown and golden, entire apical margin darker than remainder. Ninth segment narrowed dorsally. Tenth tergite flattened, mesal excavation large, basal por-

tion divided into two sub-acute prongs; tergite hinged about midway and capable of wide dorso-ventrad movement, apical portion emarginate and rounded. Dorsal margin of apical segment of clasper covered with dense short black setae. Lateral arms semi-membranous, apex covered with a dense mass of yellowish and reddish-brown setae, fig. 11.

Rhyacophila vepulsa Milne

Holotype, male. – Salmon River, Lincoln Co., Oregon, April 26, 1935. California: Stephens Creek, S. Clara County, May 1, 1927, (E. H. Nast), 1 male, (Cal.).

Length 9.5 mm. Wings light brown, stigma darker; appendages yellowish. This species can easily be identified by its greatly elongated concave tenth tergite. Lateral arms of the aedeagus fused along ventral margin, apices close together and covered with short golden colored setae, fig. 12.

Rhyacophila vetina Milne

Holotype, male. – White River, Mt. Ranier, Washington, May 12, 1934, (W. E. Ricker).

Length 10.5 mm. Wings dark brown, except a large white spot near center of anal margin, and a small white spot in apical cells, wing with a sparse scattering of short silver colored hairs. Tenth tergite long, concave, ventral margin deeply incised, apex deeply emarginate. Dorsal part of aedeagus massive, short, reaching only to margin of basal segment of clasper, ventral plate with mesal lobe long, sub-acute, fig. 13.

Rhyacophila visor Milne

Holotype, male. – Cultus Lake, B. C., August 12, 1934, (W. E. Ricker).

Length 9 mm. Wings light brown, covered with short golden colored hair; appendages yellowish. This species can easily be differentiated from other described species by its very short tenth tergite which is largely withdrawn into the ninth segment, actually only the acute, convergent apices are exposed. Aedeagus very short, dorsal plate concave, apex divided into a pair of ventrad directed hooks; ventral plate largely hidden beneath dorsal plate, its distal portion tubular, acute, gently curved dorsad, fig. 14.

Rhyacophila vobara Milne

Holotype, male. – Revelstoke Mt., B. C., elevation 6000 feet, August 12, 1923, (E. R. Buckell).

Length 10 mm. Wings luteus, lightly irrorate, stigma darker; appendages yellowish. Apical segment of clasper nearly square, ventral corner produced into a short finger-like projection. Tenth tergite, from dorsal, appears barrel-shaped, two acute projections produced by mesal emargination. Basal two-thirds of aedeagus semi-membranous, apical part consists of a dorsal tubular process whose apex is expanded and flattened; lateral arms convergent, shorter than dorsal plate, apices covered with short spines, ventral plate same length as lateral arms, distally tubular, fig. 15.

Rhyacophila vocala Milne

Holotype, male. – Cultus Lake, B. C., July 14, 1935, (W. E. Ricker) Washington: Paradise Valley, Ranier Nat. Park, July 18, 1936, (E. C. Van Dyke), 1 male, 1 female, (Cal.); Wennatche River, Merritt, June 9, 1948, (D. G. Denning), 1 male.

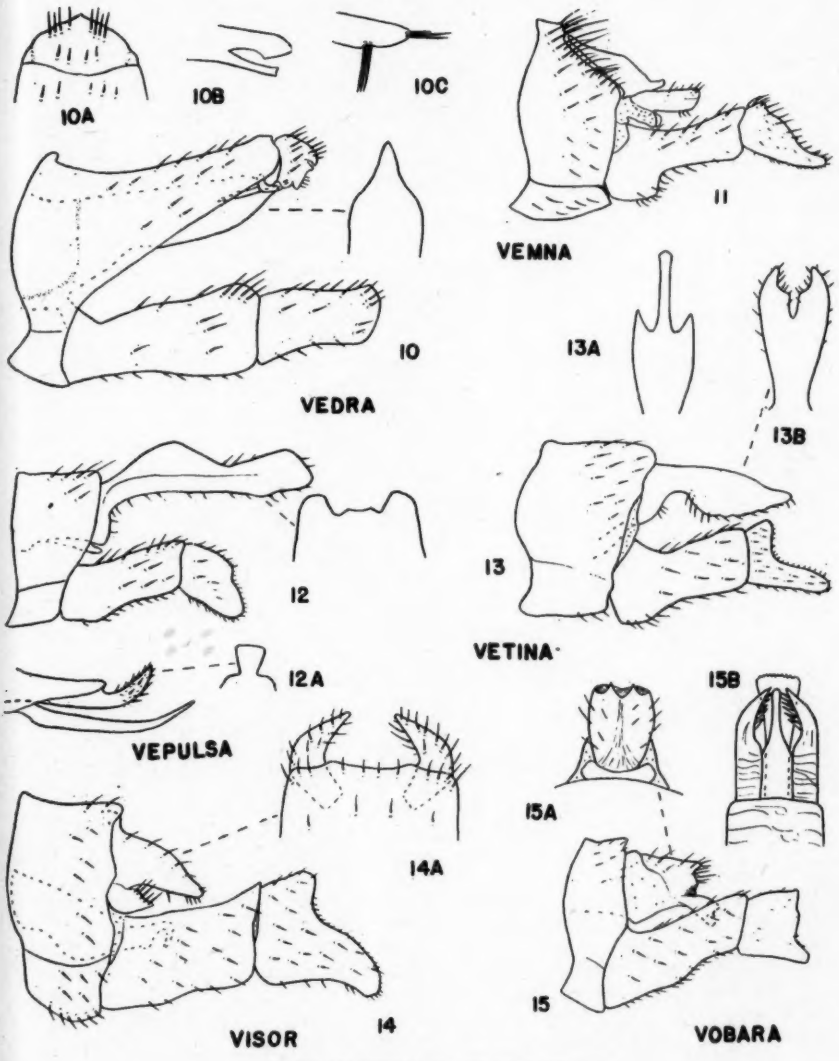
Length 13 mm. Forewings irrorate, yellowish, stigma of both fore and hind wings dark brown; appendages yellow. The peculiar apical segment of the clasper, its dorsal margin incised and its ventral margin arcuate will serve for quick identification of this species. Ninth tergite produced caudad one-half distance of tenth tergite. The tenth tergite is divided into two, thin, plate-like lateral lobes. Lateral arms of aedeagus tubular, semi-membranous, apex bearing a large and several small spines, fig. 16.

Fig. 10.

Fig. 11.
Fig. 12.

Fig. 13.

Fig. 14.
Fig. 15.



EXPLANATION OF PLATE III

Fig. 10. *Rhycophila vedra,* male genitalia, lateral aspect; 10A, tenth tergite, dorsal aspect; 10B, apex of carinate process, lateral aspect; 10C, apex of ventral process of aedeagus, lateral apect.

Fig. 11. *Rhyacophila vemna,* male genitalia, lateral aspect.

Fig. 12. *Rhyacophila vepulsa,* male genitalia, lateral aspect; 12A, carinate process of aedeagus with ventral aspect of apex.

Fig. 13. *Rhyacophila vetina,* male genitalia, lateral aspect; 13A, ventral sheath of aedeagus, ventral aspect; 13B, tenth tergite, dorsal aspect.

Fig. 14. *Rhyacophila visor,* male genitalia, lateral aspect; 14A, tenth tergite, dorsal aspect.

Fig. 15. *Rhyacophila vobara,* male genitalia, lateral aspect; 15A, tenth tergite, dorsal aspect; 15B, aedeagus, ventral aspect.

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Rhyacophila vujuna Milne

Holotype, male. – Dodge Park, Bull Run, Oregon, June 21, 1923, (R. E. Dimick).

Length 10 mm. Wings light brown, appendages about same color. Viewed dorsally tenth tergite apically narrowed, emargination short, apical lobes rounded; from lateral view the ventral process appears semi-circular, very heavily sclerotized. Apical segments of clasper convergent from either dorsal or ventral view. Lateral arms of aedeagus wide, flat, apically fringed with dense reddish-brown setae; remaining structures short, entirely enclosed by large lateral arms which are quite closely appressed, fig. 17.

Rhyacophila vuphipes Milne

Holotype, male. – Goshen, New York, September 8, 1910.

Length 11 mm. Wings dark brown, irrorate, a scattering of golden, brown and silver colored hairs over wing; appendages yellowish, spurs dark brown. Ninth sternite greatly reduced. Tenth tergite a narrow flattened plate, ventral part hinged, directed ventro-caudad. Apical segment of clasper very short, triangular. Entire aedeagus fused into a semi-membraneous tubular structure; ventral plate bluntly acute, quite heavily sclerotized, lateral arms reduced to a small invaginated structure bearing several long spines apically, dorsal portion short, heavily sclerotized, fused to ventral plate, fig. 18.

Rhyacophila vuzana Milne

Holotype, male. – McKinzie Bdg., (Bridge) Oregon, September 21, 1934, (R. E. Dimick).

Length 11 mm. Wings luteus, stigma darker; appendages yellowish. Ninth segment greatly expanded dorsally. Tenth tergite concave, from dorsal view widely emarginate, a black pigmented spot at apex of each lobe; ventral portion consists of two opposing structures, the dorsal part widely emarginate, apical lobes black pigmented, ventral part cleft entire length, lateral lobes truncate, apex black pigmented, flared dorsad laterally. Apical segment of clasper elongate. Lateral arms of aedeagus large, semi-membranous, mesal surface covered with a dense mat of long reddish-brown setae which do not extend to apical margin and only slightly beyond ventral margin; dorsal plate short, flat, truncate, fig. 19.

Rhyacophila karila, n. sp.

This species bears little resemblance to other described species and can easily be recognized by the peculiar ninth segment.

Male. – Length 7.5 mm. Forewings uniformly light brown, hind wings a trifle lighter in color. Body, antennae and legs yellowish.

Genitalia as in fig. 23. Ninth tergum considerably extended caudad so that the greatest width and length of the segment is about equal; viewed laterally the tergum is narrowed caudally with the caudal margin projected slightly dorsad and caudad beyond most of tenth tergite; viewed dorsally the caudal margin of the ninth tergum truncate, fig. 23. Tenth tergite from lateral aspect appears as a wide plate whose caudal margin is arcuate and the ventral corner rounded; viewed dorsally the dorsal margins widely separated, ventral margins nearly contiguous; from caudal view ventral margin with a short narrow incision. Claspers with basal segment short, does not extend caudad beyond tenth tergite, practically same width throughout; apical segment narrowed distally to a blunt apex, outer surface concave. Aedeagus with dorsal process, from dorsal view, narrowed toward center, greatly widened apically with lateral plates folded ventrad; carinate process, lateral view, with a long slender acute dorsal arm, and a slender acute, longer ventral arm; ventral process slender, acute, and shorter than above.

Holotype. Male. – Dyerville, California, June 17, 1935, (H. J. Rayner), (Cal). Deposited in the California Academy of Sciences.

Rhyacophila neograndis, n. sp.

This species is a member of the *vao, brunnea, grandis* group and is most closely related to *grandis*. It can be distinguished from *grandis* not only by its smaller size and lack of golden spots scattered over the forewings but in several differences in the genitalia. The ninth tergum extends over the base of the tenth tergite only slightly, and is truncate rather than widely emarginate, tenth tergite shorter and wider and is cleft for one-half its length rather than one-third as in *grandis;* apical segment of clasper with wide deep incision, ventral lobe more slender and pointed; lateral arms with a dense brush of spines apically instead of several large prominent claws. For purposes of comparison the lateral arms of *grandis* ventral aspect, are shown in fig. 25.

Male. – Length 12-13 mm. Color of forewings brownish, stigma darker than remainder of wing, very little indication of flecking. Legs yellowish, spurs a trifle darker.

Genitalia as in fig. 24. Ninth sternite extends caudad beyond remainder of segment, ventral margin arcuate; ninth tergite projected dorsad, width equal to base of tenth tergite, projected caudad only slightly beyond base of tenth, caudal margin approximately truncate. Tenth tergite with ventral and dorsal margins curved dorsad, structure extends caudad slightly beyond base of apical segment of clasper, from dorsal aspect cleft one-half of length, apices divergent, mesal surface bearing a number of scattered setae directed mesad. Basal segment of clasper with base wide, gradually narrowed distally; apical segment with wide and deep incision, the ventral lobe long, slender, entire caudal margin bearing dense, short black setae. Aedeagus with mesal process slender and reaching to base of apex of lateral arms, lateral arms relatively short, semi-membranous, apex a dense acute brush of reddish-brown spines, fig. 24A.

Holotype. Male. – Mt. St. Helena, California, April 5, 1936, (H. J. Rayner), (Cal.).

Paratype. 1 male; Strawberry Canyon, Berkeley Hills, Alameda Co., California, May 8, 1936, (H. J. Rayner), (Cal.). 1 male; Fort Seward, California, June 4, 1935, (E. W. Baker), (Cal.). 1 male; Spring Mountains, Sonoma Co., California, April 10, 1938, (E. C. Johnston), (Cal.).

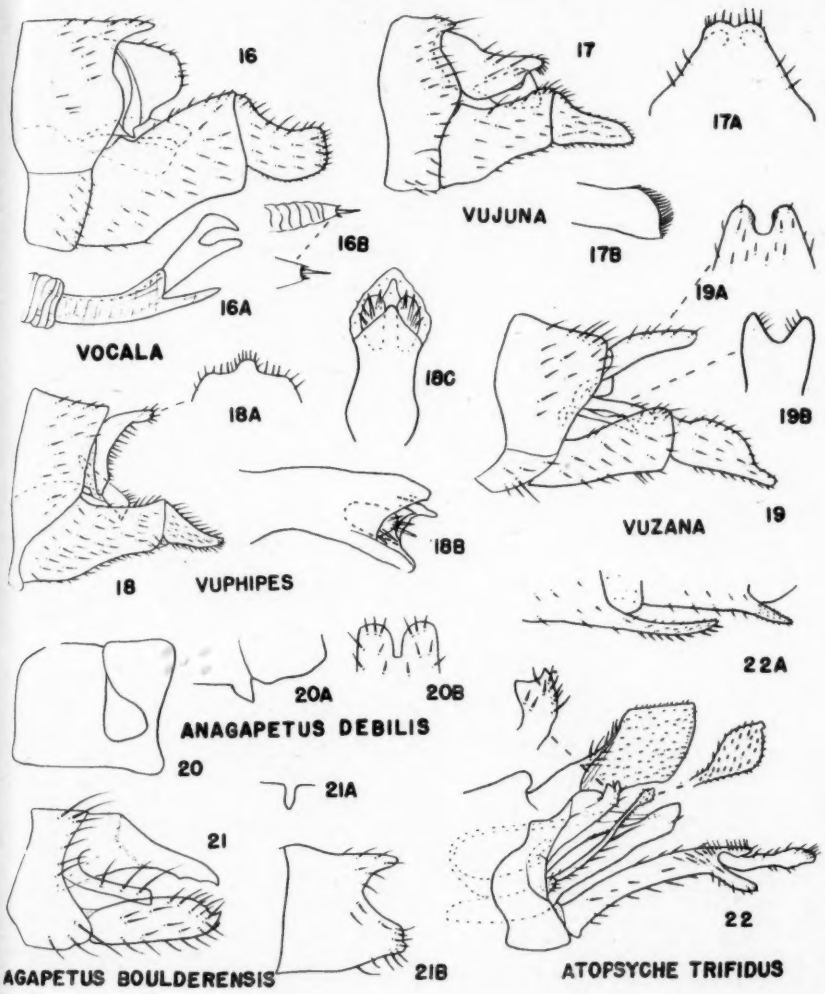
Holotype and one paratype deposited in the California Academy of Sciences.

Rhyacophila sonoma, n. sp.

This species is closely related to *vocala* Milne. It can easily be distinguished from *vocala* by its smaller size, dark colored wings, shape of the ninth segment, the much deeper incision of the ninth tergum, the apical segment of the clasper which is rounded and gradually narrowed distally, and the apically wide ventral sheath of the aedeagus which is divided into two lateral folds.

Male. – Length 12-13 mm. Forewings dark brown throughout, fore and hind wings with stigma dark. Legs yellowish, spurs dark brown.

Genitalia as in fig. 26. Ninth segment widened in the center, tergum extended caudad a short distance beyond remainder of segment, mesal incision wide and deep, fig. 26. Tenth tergite divided into two thin lateral plates, ventral margin sub-acute. Basal segment of clasper only slightly longer than greatest depth; apical segment tapering gradually to a rounded apex, ventral margin nearly straight, directed slightly ventrad. Structures in association with aedeagus very similar to *vocala*, except ventral branch of carinate process widened basally and apex blunt when viewed laterally, bifid from ventral aspect, ventral sheath with its dorsal semi-membranous arms



EXPLANATION OF PLATE IV

Fig. 16. *Rhyacophila vocala*, male genitalia, lateral aspect; 16A, carinate process, lateral aspect; 16B, apex of lateral arm.

Fig. 17. *Rhyacophila vujuna*, male genitalia, lateral aspect; 17A, tenth tergite, dorsal aspect; 17B, apex of lateral arm, lateral aspect.

Fig. 18. *Rhyacophila vuphipes*, male genitalia, lateral aspect; 18A, tenth tergite, dorsal aspect; 18B, aedeagus, lateral aspect; 18C, aedeagus, ventral aspect.

Fig. 19. *Rhyacophila vuzana*, male genitalia, lateral aspect; 19A, tenth tergite, dorsal aspect; 19B, ventral part of tenth tergite, dorsal view.

Fig. 20. *Anagapetus debilis*, female genitalia, lateral aspect of fifth segment; 20A, lateral aspect of sixth segment; 20B, ventral aspect of eighth segment.

Fig. 21. *Agapetus boulderensis*, male genitalia, lateral aspect; 21A, mesal process of sixth segment; 21B, female genitalia, lateral aspect of eighth segment.

Fig. 22. *Atopsyche trifidus*, male genitalia, lateral aspect; 22A, sixth and seventh sternite, lateral aspect.

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slender throughout, distal portion divided laterally into two distinct folds, the most dorsal portion wide and truncate apically when viewed from dorsal or ventral aspect, the most ventrad mesal fold rounded apically and originating near apex of above mentioned dorsal arms, fig. 26A.

Holotype. Male. – Sonoma County, California, April 20, 1911, (J. A. Kusche), (Cal.).

Paratype. Male. – Sequoia National Park, California, altitude 3000-5000 feet, April 27, 1928, (E. C. Van Dyke), (Cal.).

Holotype deposited in the California Academy of Sciences.

Anagapetus debilis Ross

At present this species is known from one male collected at Logan Canyon, Utah. The previously unknown female of this interesting species is described herein.

Female. – Length 6 mm. Essentially similar in color and general sructure to male. Fifth segment with a prominent truncate process, fig. 20, the dorsal margin of which is extended laterad so that when viewed from the ventral or dorsal aspect it appears as an auriculate process. Mesal projection of sixth sternite short, triangular from lateral aspect, fig. 20A, obtuse from ventral aspect. Eighth sternite with a deep narrow incision, fig. 20B.

Allotype. Female. – Beaver, Utah, June 26, 1942, (C. P. Alexander), 8000 feet elevation.

Utah: Beaver, June 26, 1942, 8000 feet elevation, (C. P. Alexander), 9 males, 4 females; Logan Canyon, June 30, 1942, 5200 feet elevation, (C. P. Alexander), 2 males, 1 female.

Up to the present seventeen species have been described in the genus *Agapetus*. Very little is known concerning the distribution of any of these species.

Agapetus boulderensis Milne

This small black species (length 3.5-4 mm.) occurs commonly along swiftly flowing streams throughout Wyoming and northern Colorado. Approximately 300 specimens collected between August 3 and October 8.

The lateral aspect of the male genitalia is shown in fig. 21. A certain amount of variation is exhibited in the apex of the cercus, and in the apical margin of the clasper. The large ovate organs of the fifth segment occupy most of the lateral portion of the segment. Mesal process of the sixth sternite, fig. 21A, slender, directed ventrad, practically identical in female. Female genitalia, lateral aspect as in fig. 21B.

Agapetus iridis Ross

This species was recently described from New York. This is the second record of its occurence.

Massachusetts: East Amherst, June 23, 1929, (J. F. Hanson), 1 male, (Mass.).

Agapetus rossi Denning

Until now this species was known only from northern Minnesota.

Massachusetts: Amherst, June 9, 1939, (J. F. Hanson), 3 males, 1 female, (Mass.).

Agapetus tomus Ross

Originally described from Georgia this constitutes an interesting record.

Kentucky: Green County, May 4, 1947, (P. H. Harden), 1 male.

Atopsyche trifidus, n. sp.

This is the seventh species in the genus described from North America. Of the described species it is closest to *majada* Ross, but is very different from it and other described species in possessing three lobes

at the apex of the clasper, in the peculiar cercus, the aedeagus and its sclerotized rod and several other characters of the genitalia.

Male. – Length 6.25 mm. Color of wings light brown, appendages yellowish except fore and middle tibia lightly banded. Spurs 2-4-4. Sixth and seventh sternites with prominent mesal processes, the sixth extending nearly to the seventh and bearing a number of prominent spines, fig. 22A. Genitalia as in fig. 22. Ninth and tenth tergites form a sub-truncate flattened process when viewed dorsally, and a large prominent narrow mesal projection which extends considerably caudad, covered with minute setae and lightly sclerotized. Cerci long and slender bearing several large setae, apex enlarged and covered with minute setae, fig. 22; paracercal process heavily sclerotized, apex bifid; apices divergent from dorsal aspect. Clasper long, slender, apex of basal segment divided into a small dorsal and a much larger ventral lobe; between these arise the long slender apical segment, the latter markedly convergent from dorsal view. Aedeagus with a narrow base, extending caudad as a somewhat flattened structure, concave from dorsal view, apex with a deep emargination, the resultant lateral lobes apically rounded; sclerotized rod with straight dorsal acuminate arm which extends caudad nearly to apex of aedeagus.

Holotype. Male. – Luquillo, Puerto Rico, October 29, 1943, Light trap, (H. D. Pratt).

Glossosoma califica, n. sp.

This species belongs to the *alascense* group and is most closely related to *pterna* from which it can be distinguished by the apically enlarged tenth tergite, the slender, evenly rounded basal portion of the cercus, the attenuated apex of the clasper and the thicker aedeagus.

Male. – Length 9.5 mm. Color light brown, appendages yellowish. Mesal process of sixth sternite broad and round, of seventh sternite short and conical. Genitalia as in fig. 27. Ninth segment produced into a pair of large thin flaps forming a hood over most of genitalia, caudal margin sinuate, apex broadly rounded, ventro-caudal corner produced into a conical process bearing a cluster of long setae along ventral surface. Tenth tergite with mesal portion semi-membranous, the lateral sclerotized lobes extend caudad to edge of hood, center portion narrowed, greatly widened apically, dorso-caudal corner sub-acute. Cerci with basal portion evenly rounded, remainder slender and acuminate, gradually curved dorsad to a point practically level with ninth tergum; just ventrad from base of apex, along mesal surface, appears a rather short single row of small setae. Claspers with deep incision near base, remainder of structure with ventral margin sinuate, dorsal margin arcuate, apex long, slender, acute. Aedeagus with dorsal surface flattened from lateral aspect, concave from dorsal view, apex semi-membranous; ventral rodlike structure extends caudad beyond base of clasper, broadly rounded from ventral aspect.

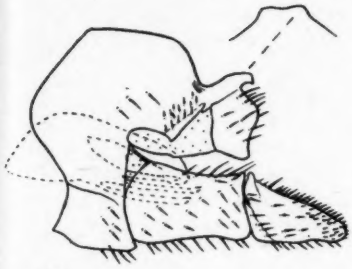
Holotype. Male. – Independence, Inyo County, California, June 12, 1929, (R. L. Usinger), (Cal.).

Deposited in the Academy of Sciences.

Glossosoma mereca, n. sp.

This species can easily be distinguished from other described species by the horn-like processes of the tenth tergite, the long sinuate acute aedeagus and the short tapering claspers.

Male. – Length 8 mm. Apparently diagnostic characters are confined to the genitalia. Mesal projection of sixth sternite broad, flat and rounded, and of seventh segment short and conical. Genitalia as in fig. 28. Ninth segment produced into a pair of thin flap-like structures which form a hood over most of the genitalia, dorsal and lateral margins sinuate, apex



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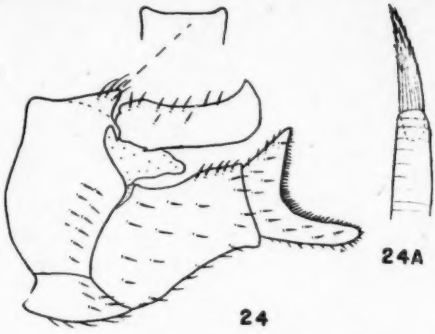
RHYACOPHILA KARILA



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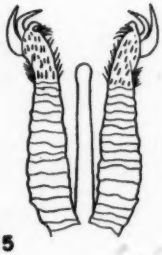
RHYACOPHILA NEOGRANDIS



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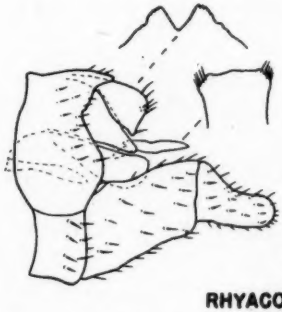
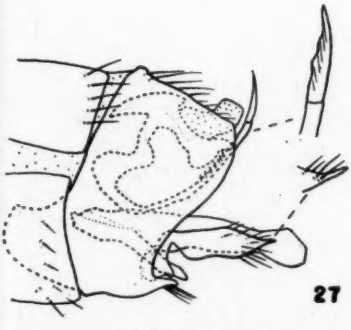
RHYACOPHILA GRANDIS



26

26A

RHYACOPHILA SONOMA



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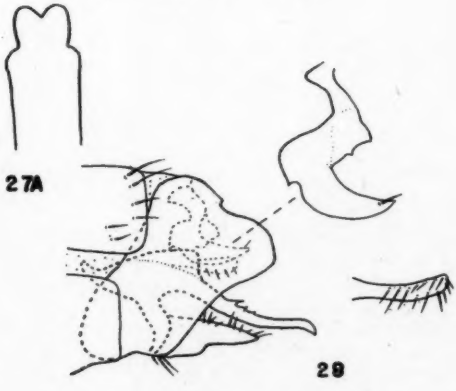

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GLOSSOSOMA CALIFICA

GLOSSOSOMA MERECA

EXPLANATION OF PLATE V

Fig. 23. *Rhyacophila karila,* male genitalia, lateral aspect.
Fig. 24. *Rhyacophila neograndis,* male genitalia, lateral aspect; 24A, apex of lateral arm of aedeagus.
Fig. 25. *Rhyacophila grandis,* male genitalia, ventral aspect of lateral arms of aedeagus.
Fig. 26. *Rhyacophila sonoma,* male genitalia, lateral aspect; 26A, ventral sheath of aedeagus.
Fig. 27. *Glossosoma califica,* male genitalia, lateral aspect; 27A, ventral aspect of aedeagus.
Fig. 28. *Glossosoma mereca,* male genitalia, lateral aspect.

broadly rounded, setation rather heavy along lateral and dorsal margins. Tenth tergite with mesal portion flat, truncate from lateral view; contiguous from ventral view; lataral portion developed into a large prominent horn-like process, apex acute and bearing a single seta near apex, fig. 28. Cerci slender, apex blunt, extends caudad almost as far as tenth tergite, setae prominent, directed ventrad, fig. 28. Claspers with base wide and rounded, apical portion with ventral margin straight, tapering to an acute apex; divergent from ventral view; dorso-mesal margin flattened with setation sparse. Viewed laterally aedeagus appears as a long, sinuate, acuminate structure, bearing two prominent teeth bout midway along dorsal margin; seen from ventral aspect the two apices are convergent, their acute tips almost touching; mesal process discernable best from ventral aspect, semimembranous, apex incised with each lateral half bluntly acute.

Holotype. Male. – Mereca River, Yosemite, California, altitude 3880-4000 feet, June 28, 1936, (H. J. Rayner), (Cal.).

Deposited in the California Academy of Sciences.

CATALOGUE OF THE ODONATA OF CANADA, NEWFOUNDLAND AND ALASKA by Francis C. Whitehouse. 56 pages. Transactions of the Royal Canadian Institute, Vol. XXVII, No. 57, October, 1948 (Reprint).

Since the turn of the present century, Canadian species of Odonata have been collected and studied quite comprehensively. The present catalogue is in the nature of a preliminary catalogue of 18 species occurring in America north of the international boundary.

From recorded data, such established facts as the distribution, life zones (Merriam's) within the territory covered, and flight periods are given for each species. Selected references are also included. No attempt has been made to include full bibliographies. Each species listed is given two numbers: the first for the purpose of the present catalogue; the second for the purpose of reference to Muttowski's catalogue to which the reader is referred for full bibliographies of species described prior to 1910.

This catalogue, by a former student, is a personal tribute to Dr. E. M. Walker of the University of Toronto, who for over forty years has been an ardent student of the Odonata. As a professor he has been a source of inspiration to those individuals fortunate enough to have worked with him. The author attributes over eighty percent. of the records on which this catalogue is based to the work of Dr. Walker, much of which has been published in The Canadian Entomologist.

R. H. Ozburn.

THE BIOLOGY OF *MELANICHNEUMON RUBICUNDUS* (CRESS.) (HYMENOPTERA, ICHNEUMONIDAE) *

BY GEORGE WISHART
Dominion Parasite Laboratory, Belleville, Ontario.

In a previous paper the writer stated that only two native parasites, *Labrorychus prismaticus* (Nort.) and *Aplomya caesar* (Aldrich), regularly attack the European corn borer, *Pyrausta nubilalis* (Hubn.) in Canada. *Melanichneumon rubicundus* (Cress.) is occasionally reared from the corn borer in the Eastern United States and a few adults were received with some adults of the European parasite *Phaeogenes nigridens* Wesm. A breeding stock was established with a view to possible future liberations in areas in Canada where it has not been recorded. It was found however, that while *M. rubicundus* will attack the corn borer in the laboratory it does so with such a degree of reluctance that it must be assumed that the attack in the field occurs only in the absence of more desirable hosts. In the laboratory this parasite attacks *Loxostege sticticalis* (L.) very readily and the data presented herewith are from material reared on *Loxostege*.

Distribution and Hosts

M. rubicundus has been recorded from Ontario (Sudbury) and Quebec and from the following states, [(Townes) (17)]: Connecticut, New Hampshire, Maine, New York, Massachusetts, North Carolina, Virginia, Illinois, Kansas and Texas.

Only two hosts have been recorded in the literature, *Macronoctua onusta* Grote (Lepid.), [(Breakey) (2)], and *Neodiprion abietis* (Harr.) (Hymen.), [(Norton) (8)]. Clausen (3) states "The species of the subfamily Joppinae are consistent in their host preferences and are recorded only as internal parasites of the larvae and pupae of *Lepidoptera*." The record of attack on *N. abietis* must therefore be viewed with reservations.

Synonomy

The female (Figure 1.) of this parasite was first described by Cresson (4) in 1864 and the male in 1877 [(Cresson) (5)] as *Ichneumon rubicundus*. Townes [(17), (1944)], places it in the genus *Melanichneumon* with the following synonomy:

Ichneumon rubicundus, Cresson, Proc. Ent. Soc. Phila., 1864, 3:176.—Norton, Trans. Amer. Ent. Soc., 1869, 2:326. — Cresson, Trans. Amer. Ent. Soc., 1877, 6:184. — Provancher, Nat. Canad., 1882, 13:311, 326. —Evans, Can. Ent. 1896, 28:10. — Bridwell, Trans. Kans. Acad. Sc., 1899, 16: 204. — Nason, Ent. News, 1905, 16:148. — Townes, Ent. News, 1939, 49:219.

Ichneumon mucronatus, Provancher. Nat. Canad., 1875, 7:24, 81. — Provancher, Nat. Canad., 1878, 10:273, 364.

Amblyteles mucronatus, Johnson, Pub. Nantucket Maria Mitchell Assoc., 1930, 3, No. 2:98.—Breakey, Ann. Ent. Soc. Amer., 1931, 24:43.—Brimley, Insects of N.C., 1938, 404.

Amblyteles rubicundus, Cushman, Journ. Wash. Acad. Sc., 1925, 15:289. — Johnson, Biol. Surv. Mt. Desert Region, 1927, 1:145. — Cushman, Mem. Cornell Univ. Agr. Exp. Sta., 1928, 101:925. — Brimley, Insects of N.C., 1938, p.405.

Ichneumon blanchardi, Davis, Trans. Amer. Ent. Soc., 1898, 24:350.

Melanichneumon rubicundus, Townes, Mem. Amer. Ent. Soc., No. 11, 1944, Pt. 1. p.328.

*Contribution No. 2548, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

Description of Immature Stages

Egg

The newly laid egg (Figure 2) has an average length of 1.02 mm. and an average width of .26 mm. It is oblong-ovate in shape, slightly arched and somewhat smaller at the caudal end than at the cephalic. For the most part the eggs are hyaline but some have a distinct yellowish or greenish colour. Age of the egg is not a factor in this variation in colour.

Larva

The difficulty of determining with accuracy the number of larval instars in internal ichneumonid parasites has been mentioned by many authors, including Smith (14) and Clausen (3). The present study has been no exception. In the laboratory, superparasitism was the rule rather than the exception; hence little could be deduced from the number of cast head capsules found. After many dissections it was concluded that the size and form of the mandibles were more accurate criteria for the differentiation of the instars than the size and form of the head capsules and that they suffered less from the distortion incident to dissection and mounting for examination. The evidence that there are three larval instars is reasonably conclusive.

First Stage Larva

When hatched the larva (Figure 3) is 1.39 mm. long and .34 mm. wide. It is 3.3 mm. long when full grown. Exclusive of the head it has 13 segments and is subcylindrical in shape being somewhat flattened dorso-ventrally, widest at the thoracic region and tapering toward the caudal end. It has the lateral folds characteristic of most parasitic Hymenoptera. It is transparent white in color except insofar as the ingestion of food makes the digestive tract appear yellowish and opaque. The head capsule (Figures 4 and 5) is flattened dorso-ventrally and sclerotized, particularly the mandibles. The labrum is bilobed and has a raised portion near the apex of each lobe, presumably sensory in nature.

Internally, the first stage resembles larvae of other species of ichneumonids already described [(Seurat) (11)], [(Smith) (14)]. The digestive tract is well developed, the stomach reaching from the fore part of the first thoracic segment to the seventh abdominal segment and being quite opaque from shortly after emergence onward. The hind intestine in this stage is short, narrow, and quite transparent. The tracheal system (Figure 3) is similar to that of *P. nigridens* [(Smith) (14)] and has the two secondary lateral trunks, first described by Seurat (12), running from the posterior margin of the first thoracic segment to the anterior margin of the first abdominal segment. No spiracles were observed.

Second Stage Larva

At the beginning of the second stage the larva is about 3.5 mm. long and at the end approximately 6 mm. long. In shape it is very similar to the first stage and only by careful examination of the head capsule and the mandibles (Figure 6) is it possible to separate them. The mandibles are slightly larger, the basal part is broader and in general they are less sickle shaped than in the first stage. The treacheal system is similar and there are no spiracles. In *P. nigridens,* Smith (14) records that spiracles are present but closed in the second stage.

Third Stage Larva

Freshly moulted third stage larvae are approximately 6 mm. long and attain at maturity a length of almost 9 mm. In the third stage larva the head, which in the second stage is flattened dorso-ventrally, is flattened some-

what in the vertical plane with the mouth parts pointing somewhat ventrally. Within twenty-four hours the larva develops a distinct thoracic hump. Smith (loc. cit.) records the same for *P. nigridens* and explains its presence by the necessity of the larva feeding in cramped quarters requiring the thorax to be bent at right angles. This seems to be a reasonable hypothesis. He states that to his knowledge this hump has never been recorded in any other ichneumonid. It is probable that when more of the Phaeogeninae are studied the same form will be found. After the hump appears the larva is quite different in appearance from the other stages.

The head (Figure 7) is transparent except for the sclerotized parts which are light brown. The mandibles are stouter and less hooked than those of the other stages and a little greater in overall length. The hypostoma and pleurostoma are distinct thickened bands and are heavily sclerotized. The epistoma is complete but is transparent and is most easily seen in overstained preparations.

The tracheal system (Figure 8) has six pairs of spiracles, one pair in the posterior margin of the first thoracic segment, and one pair in the anterior margin of each of abdominal segments one to five. In abdominal segments six, seven, and eight short pointed tracheal "stumps" occur on the tracheal trunks in the same position as attachment of the spiracles in segments one to five. These are, apparently, vestiges of the connections of spiracles which were present in more primitive forms. Some variation occurs in individuals in the size of these "stumps" but in no case observed was any of the three pairs lacking. Smith (loc. cit.) indicates that *P. nigridens* has nine pairs of spiracles in the ultimate larval stage. While it is doubtful if the number of spiracles can be used as a specific character the variation between the numbers in these two species may be of use to assist in determination where the larvae encountered are in a host common to both parasites.

The spiracles (Figure 9) are similar in general form to those of other Ichneumoninae as described by Beirne (1) except that the "short, annularly thickened stalk" leading to the thick-walled closing apparatus is much shorter than those figured in his paper. It is, in fact, so short as to be difficult to differentiate, the atrium appearing to connect directly with the closing apparatus.

Prepupa

The prepupa has no features to distinguish it sharply from that of other parasitic Hymenoptera. The larval hump so evident in the third larval stage is now absent. The imaginal eyes are apparent in the first thoracic segment.

Pupa

Length, 9 mm.; width, 2.1 mm.

The pupa (Figure 10) almost completely fills the host pupal case, the abdomen of which is somewhat distended. Thus the length of the parasite pupa is approximately the original length of the fresh host pupa from which it will emerge. A partial silken cocoon encloses the anterior portion of the pupa.

Reproductive Organs of the Female

The female reproductive organs (Figure 11) are of the Ichneumon type [(Pampel) (10)]. There are two ovaries each with three, four, or five ovarioles. Individual females may be asymetrical, one ovary consisting of three or four ovarioles and the other of four or five. The ovarioles are bound together at the cephalic end by an ovarial ligament and those of the two ovaries are joined dorsad of the alimentary canal. The ovarioles

are of the polytropic type [(Snodgrass) (15)], an oocyte alternating with a group of nurse cells. There is never more than one well developed oocyte in an ovariole at one time. Several may be observed in the early stages of development but further up in the ovariole they cannot be distinguished from the germ cells. Short oviducts connect the ovaries to the common genital duct and vagina. The spermatheca is a small round flat pouch situated dorsally on the common genital duct. It is connected to the genital duct by a short spermathecal duct. The poison sack is connected to the terebra by a long canal. Attached to this canal and connected to the poison sack are the two acid glands, each of which is branched into two arms one of which is branched again. In this respect it is different from *P. nigridens* as described by Smith (14) in which case each of the two branches of the acid gland is undivided. The alkali gland is a long, sack-like, unbranched organ opening into the terebra through a narrow neck near the opening from the canal of the poison sac.

Reproductive Organs of Male

The male reproductive organs (Figure 12) consist of the paired testes, the paired vasa deferentia and a vesicula seminalis attached to each vas deferens. The vasa deferentia are joined to form a common ejaculatory duct which opens into the aedeagus. The paired testes are enclosed in a scrotal membrane thus forming a single median organ. Each testis appears to have but one follicle which is sacklike in form. The presence of but a single follicle in each testis is not surprising in view of the reduced number of the ovarioles in the female, for according to Snodgrass [(1935) (15)] the number of the testicular follicles is usually less than the number of ovarioles. The ducts leading from the testes are simple tubes without any convolutions.

Biology

When the parasites emerge, adults of both sexes contain many large cells of waste matter. These are voided in a few hours. From the time of emergence until the parasites d e of old age they are continuously active at room temperatures. The males are positively phototropic when they emerge but not markedly so. Females are slightly phototropic when they emerge but later are almost negative in their response to light in the laboratory. Their high degree of activity and their unpredictable response to light make them extremely difficult to handle in cages.

Adults of both sexes feed readily on raisins, sugar, or honey. The usual method of feeding consisted of placing droplets of honey on a piece of stiff brown paper in the bottom of the cage. Moisture was supplied by a piece of wet dental cotton.

Mating

Both sexes are ready to mate a short time after emergence. Males will continue mating actively for several weeks but after females are a few days old they do not mate readily. Both sexes will mate more than once. The act of copulation is not preceded by any prolonged courtsh p. When a female is introduced into a cage of males, the males start moving about excitedly, fluttering the wings and waving the antennae and under such conditions if a female remains stationary for a few seconds she is almost certain to be mated immediately. Copulation lasts from less than one minute to about five minutes. One mating is apparently all that is required for the production of fertile eggs during the life of the female. Mating will occur at any temperature at which the parasites are normally active.

Oogenesis

Females dissected shortly after emergence reveal well developed eggs present in the base of each ovariole. Development of the eggs thereafter is fairly rapid and viable eggs were laid by some females less than 24 hours after emergence. In *P. nigridens* Smith (14) reports that only extremely miniature eggs are present at the time of emergence. He also reports that mature eggs were not found in the ovaries of *Phaeogenes* before eleven days. Table I indicates the preovoposition period of a group of female *M. rubicundus*.

Table I. Approximate time required from emergence to oviposition in *M. rubicundus* at 75°F.

No. of individuals	No. of days, emergence to production of viable eggs.
4	1
4	2
2	3
7	4
4	5
3	6
1	10
1	14

Oogenesis continues for about six weeks when the parasites are kept at 75°F. during the day and 50°F. at night.

Oviposition

Observations on oviposition were made only under laboratory conditions and no data are available on the activities of the parasite in search of the host. In the laboratory the pupae were placed on the floor of a wooden cage containing the female parasites. Attack occurred immediately when fresh pupae were introduced. After a very short examination the parasite proceeds to puncture the pupa with its ovipositor and to deposit an egg. In the case of *Loxostege*, attack may take place in any part of the pupa but it was observed that in freshly formed pupae the bulk of the eggs were deposited in the cephalic and thoracic regions while in more mature pupae more eggs were laid in the abdominal region. This is possibly due to the hardness of the integument of tne thoracic region of the pupa as it grows older. Three hosts, *L. sticticalis* (L.), *P. nubilalis* (Hubn.) and the tenthredinid, *N. abietis* (Harr.) were used. *L. sticticalis* was attacked very readily, *P. nubilalis* rather reluctantly and *N. abietis* not at all. In the case of *N. abietis* freshly formed pupae were presented both in their cocoons and naked, but not the slightest interest was shown in either. This is at variance with the record of Norton [(1869) (8)]. In the case of *P. nubilalis*, pupae were only attacked if very freshly formed, that is, before they had completely assumed the pupal colour. On the other hand, pupae of *Loxostege* were attacked at any age up to eight days and produced normal progeny. *Loxostege* pupae remain light in colour until the formation of the imago inside makes them appear dark, while pupae of *P. nubilalis* become a medium brown colour a few hours after formation. Hardness of integument may be a factor but it is noteworthy that the females do not even attempt to oviposit in any *P. nubilalis* pupae that have turned brown. It would seem that *P. nubilalis* is not a preferred host.

Under laboratory conditions superparasitism is the rule rather than the exception. To determine if the parasites show any discrimination or restraint in the presence of previously parasitized hosts, pupae were presented as follows: a block of wood (Figure 13) 3¼ inches square with 16 slots on its surface in a 4 by 4 square pattern, with a pupa in each slot was presented to ten laying females on successive days. The pupae were dissected and the parasite eggs found are tabulated in Table 2.

Table 2. Oviposition by 10 females when 16 pupae were presented in a square, 4 pupae each way.

Position in square	Lot No. 1	2	3	4	5	6
1	0	3	1	0	2	1
2	13	1	2	0	0	0
3	1	3	0	1	0	0
4	1	2	0	0	3	2
5	3	1	2	0	2	0
6	0	1	1	1	0	0
7	0	2	0	0	0	0
8	2	3	1	0	0	0
9	2	4	4	0	0	0
10	1	5	1	1	0	1
11	2	1	1	0	0	0
12	2	1	3	0	1	0
13	5	2	1	0	0	0
14	2	3	1	0	0	2
15	1	2	1	0	0	3
16	1	3	1	1	1	1

Analysis of the data indicates that the distribution of the eggs is random. Hundreds of dissections made throughout the study also revealed that in pupae presented under similar conditions some would be left unparasitized while others would contain many eggs. It can be concluded from the data in Table 2 that the female cannot discriminate between freshly parasitized hosts and those which are unparasitized. However, it was found that if parasitized hosts were exposed some time after the contained parasites had a chance to develop, the *M. rubicundus* females could discriminate between parasitized and unparasitized hosts. This is indicated by the data in Tables 3 and 4.

Table 3. Oviposition by *M. rubicundus* in *Loxostege* pupae exposed 3 days previously.

Pupa No.	Unpar.	Parasites from 1st exposure	Eggs laid at 2nd. exposure
1			1
2		1 3rd, several dead 2nd.	
3			2
4		1 3rd, several dead 2nd.	1
5		1 3rd	
6			1
7			1
8		1 3rd	1
9		1 3rd	1
10			2

Table 4. Oviposition by *M. rubicundus* in *Loxostege* pupae exposed 4 days previously.

Pupa No.	Unpar.	Parasites from 1st exposure	Eggs laid at 2nd exposure
1		1 late 3rd	
2		1 late 3rd	
3		1 late 3rd	
4			3
5			1
6			1
7			1
8		1 late 3rd	
9	1		
10		1 late 3rd	
11	1		
12		1 late 3rd	
13			2
14			1
15			1

It will be noted that of the ten pupae (Table 3) five contained parasites from the first attack and three of these had eggs deposited in them at the time of second exposure three days later. In those exposed four days after first attack (Table 4) none of the six which were parastized at the first attack received eggs whereas seven of the nine which were unparasitized at the first exposure received eggs at the time of second exposure. In addition ten pupae were exposed a second time six days after the first exposure. The female parasites examined these with their antennae but made no attempt to oviposit. The data are not sufficient for statistical analysis but it would appear that, while the parasites cannot tell if pupae contain fresh parasite eggs, when the contained parasites reach a certain stage of development, about the 3rd instar, the parasites can discriminate between parasitized and unparasitized hosts and when they find parasitized hosts they show restraint.

In the laboratory the greatest number of eggs laid in one day by a female was eight and the greatest total 86. It is probable that each ovariole is capable of maturing not more than one egg each day.

As indicated earlier the parasite eggs may be laid anywhere in the body of the host pupa. When laid in fresh pupae where there is little tissue organization, they float freely in the body fluids. When laid in more mature pupae where the muscle structure has been partly formed they may be inserted between the muscles. Eggs were not observed imbedded in any tissue except the fat bodies.

Incubation

Incubation requires from 28 to 36 hours at 75°F. and escape from the eggshell is accomplished by the use of the mandibles. As in *Phaeogenes* [(Smith), (14)], the *M. rubicundus* larva lies straight in the egg-shell and is not folded caudally.

Larval development

The development of the larva could only be studied by making large numbers of dissections at various times after parasite attack. Feeding commences almost immediately after the larva leaves the egg-shell, so soon in fact that it is difficult to find first instar larvae that have not fed. Observation indicates that the method of feeding is the same as observed for *Phaeogenes* by Smith (loc. cit.). The mandibles in this instar are relatively large and are continuously active. The same breaking up of the fat bodies around the feeding larva was noted as in *Phaeogenes*. First instar larvae may be found anywhere in the host body but very few were found in the abdominal region and most were found toward the head. As they grow they move around and second instar larvae are found mostly in the thoracic or abdominal region, and toward the last of this instar in the abdomen only. After a large number of dissections it was concluded that the late second instar larva moves caudad until its head is close to the posterior end of the abdomen of the host. Here it casts its exuvium and then turns around until its head points cephalad. Usually it proceeds to devour the exuvium which it encounters when it turns. From this time until larval growth is complete feeding occurs on the tissues, all the organs with the exception of the main treacheal trunks being devoured. When the larva is mature it fills approximately seven-eighths of the pupal skin of the host, the free space being at the cephalic end of the pupa. The larva is oriented in the same position as the host pupa.

There is some spinning of silk by the mature larva but this consists only of a thin "cape" which extends backward to about the post-thoracic or pre-abdominal region. Such a partial cocoon can serve little purpose

and is probably the remnant of a habit carried over from a period of development when this insect did not develop in the pupal case of its host and when a cocoon was a useful protection.

As nearly as could be ascertained the length of the various stages at 75°F. was approximately as follows:

1st larval stage	1 day
2nd larval stage	1½ days
3rd larval stage	2½ days
Prepupal stage	3 days
Pupal stage	6 days.

Effect of Parasite on the Host

There is very litle escape of body fluid from the host at the time of parasite attack. After a few days, however, the point at which the ovipositor was inserted turns a medium brown color. This is a reasonably good criterion of whether or not a pupa has been stung but not a positive proof that an egg has been laid since eggs are not deposited every time a pupa is punctured. The host pupa retains its normal power of movement until the parasite reaches the third larval stage. As the parasite grows, movement produced by the host itself diminishes but a certain amount of movement occurs in the abdomen of the host produced by the movement of the maturing parasite larva which now occupies and almost fills this part of the host body. As feeding progresses the abdomen of the host becomes distended and the whole pupal shell becomes dry and hard and there is no movement whatever. At this time the remaining parts of the tracheal system can be clearly seen through the pupal case.

Emergence

At the end of pupation the head of the adult is in the prothoracic region. When ready to emerge the mouth parts are used to cut off or almost sever the part of the pupal skin which is forward of this point. The adult then wriggles out and walks away.

Elimination of Supernumerary Parasites in the Host

As stated earlier superparasitism in the laboratory is the rule rather than the exception. It also, in all probability, occurs occasionally in the field. Never, however, has more than one parasite been observed to emerge from one host. Supernumerary parasites are invariably eliminated. The term superparasitism is used here in the sense suggested by Imms (7), to denote the incidence of two or more parasites of the same species in one host. As many as fifteen eggs were found in one dissected pupa.

Fiske (6) classifies the manifestations of multiple attack by one or more species, and states that where one parasite dies and the other lives, that the survivor preys upon the other as an accidental secondary parasite or the survivor destroys the other by bringing about the premature death of the host. In the present case, the survivor preys on the other but as a predator in that it attacks and subsequently devours other competing larvae. It does not bring about the premature death of the host since it was not observed that superparasitized hosts died at an earlier date than hosts which had sustained a single attack. The long survival of the host in this case, however, is not an important factor since the host always succumbs about four days after the parasite egg is laid. Packard (9) referring to parasites of the Hessian fly states "In every instance where more than one egg or larva was placed in the same host or in the same cell, one survived and the rest were killed by that one, or starved to death. This was true whether the two or more larvae were of the same or different species". This is in agreement with the present findings.

Information on the method of elimination was secured by making hundreds of dissections of parasitized hosts at various stages of development. Undoubtedly, the most important method of elimination is by the attack of the earliest hatching larvae on those which hatch subsequently. Much evidence of mechanical damage on first and second instar larvae was observed and in several cases the actual attack was noted in freshly dissected superparasitized hosts. The large strong mandibles of the first instar larva fit it well for this attack. Whether these encounters are chance or whether the larva goes in search of competing larvae was not determined. Where there were many larvae, the process of eliminating all others required some time and in some cases was not completed until the "senior" larva was in the late second stage. In one case there was evidence that the final victory did not occur until two larvae had reached the third stage. In no case was there evidence that any but mechanical means was responsible for the death of later hatching larvae.

There was, however, some evidence that hatching of the eggs was prevented. Where many eggs were laid in one host there were often, but not always, a few which did not hatch. If the time of dissection was shortly after the normal time of hatching some of these eggs appeared to be more or less normal but some had black or melanized areas. At first it was thought that the early hatching larvae had attacked these eggs and that the melanic appearance occurred because of the lesions thus produced. However, after many dissections a few hosts were found in which no eggs had hatched and in which there were eggs with these melanic areas. There is the remote possibility that some of the eggs may have been damaged mechanically by the ovipositor of the female in ovipositing in hosts already containing eggs. If the possibility of mechanical damage is eliminated, one would have to accept the hypothesis that there is some host reaction which produces phagocytic action on the parasite eggs. Melanized eggs were never observed in hosts which contained only a few eggs and it may be that a small number of eggs does not cause this reaction while a larger number may.

No observable effect was noted on the surviving parasite either in its size or fecundity. It was thought that the developmental period might be longer due to the competition involved but experimental data did not bear this out. In a group of pupae parasitized many times and a group parasitized only once the results are comparabe (Table 5).

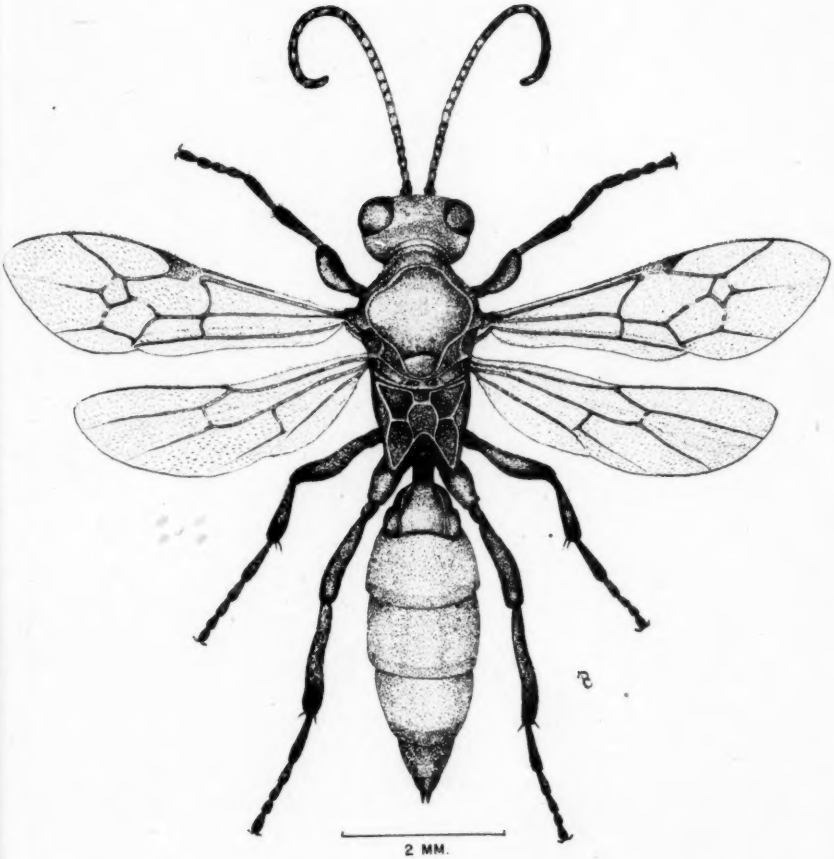
Table 5. Effect of superparasitism on parasite development.

	Parasitized once	Parasitized many times
No. of examples ♂ ♂	644	39
No. of examples ♀ ♀	249	12
Average time egg to adult ♂ ♂	15.38 days	15.87 days
Average time egg to adult ♀ ♀	16.29 days	17.41 days
Percentage females	27.8	23.5

The number of examples of those parasitized many times is not large but it would appear that there is no significant difference in developmental time. The same is true with regard to sex ratio. Usually in rearing hymenopterous parasites in the laboratory any adverse condition militates against the production of females. It must be concluded that superparasitism has little, if any, adverse effect on the survivors.

Sex Ratio

In the first few generations of *M. rubicundus* reared the females were slightly more numerous than the males (56% females) and it is presumed that this condition obtains in the field. After several generations in the



1. Adult female.

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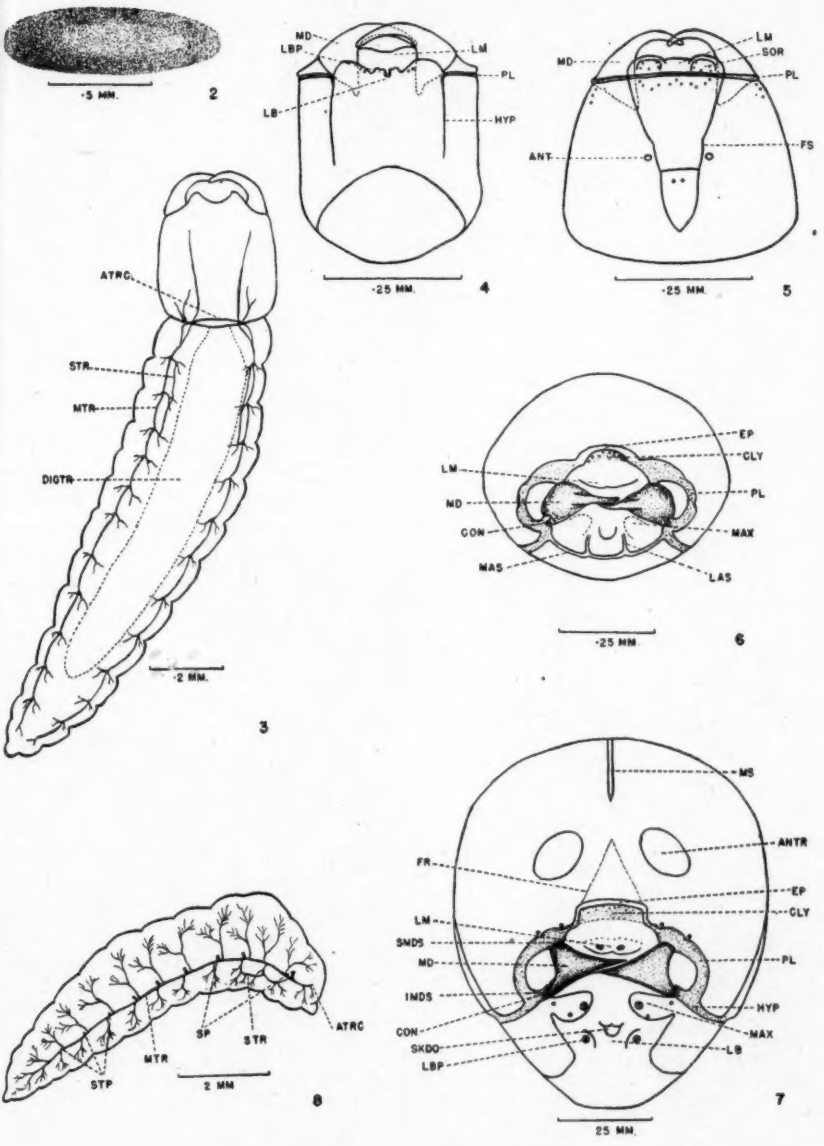
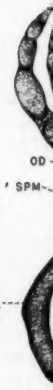
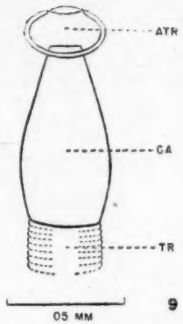


EXPLANATION OF FIGURE

2. Egg.
3. First stage larva, showing tracheal system.
4. Firt stage larva, head capsule, ventral view.
5. First stage larva, head capsule, dorsal view.
6. Second stage larva, head capsule, cephalic view.
7. Third stage larva, head capsule, cephalic view.
8. Third stage larva, lateral view, showing tracheal system.



9. Thor
10. Pupa
11. Repr
12. Repr



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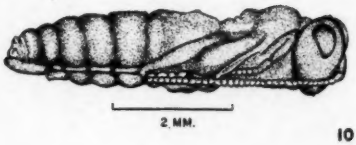

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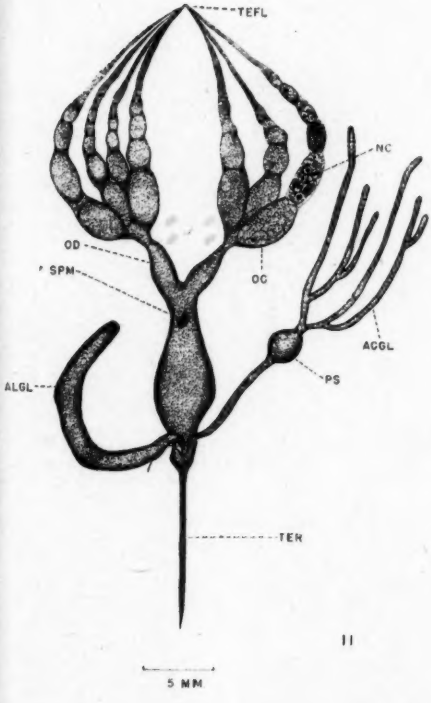

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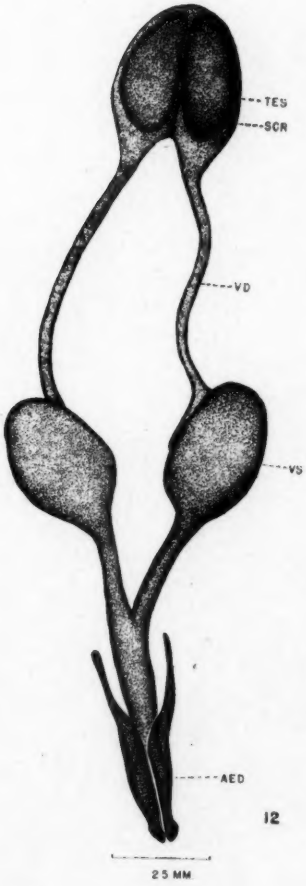

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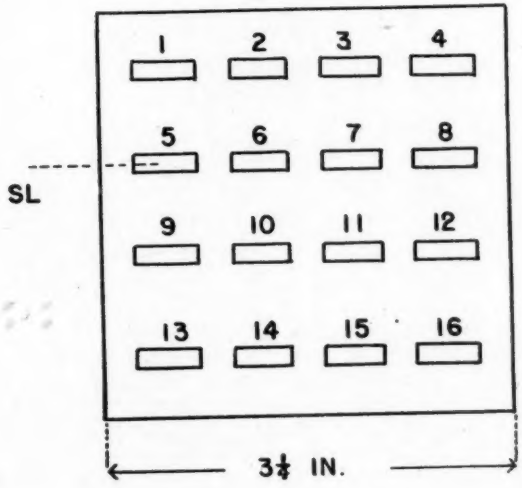
EXPLANATION OF FIGURES

9. Thoracic spiracle, third stage larva.
10. Pupa, female.
11. Reproductive system, female.
12. Reproductive system, male.

13. Dia



13. Diagram of block used in discrimination experiment.

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laboratory the proportion of females became markedly less. This is a common occurence in the laboratory and the reasons have been discussed by Simmonds (13). Table 6 summarizes the data pertaining to the sex ratio of the progeny of ten females.

Table 6. Sex of progeny of ten mated females, *M. rubicundus*.

Female No.	♂ ♂	♀ ♀	Percentage ♀ ♀
1	28	17	37.7
2	57	20	25.9
3	70	22	23.9
4	33	32	49.2
5	67	11	14.1
6	25	9	26.4
7	21	2	8.6
8	45	30	40.0
9	25	25	50.0
10	13	25	65.7
	384	193	33.45

The species is arrhenotokous, unfertilized females producing only males.

Hibernation

It is well known that some and perhaps many of the Ichneumonidae pass the winter as adults. Seyrig (12) states that in Europe 20 species of Phaeogenini hibernate as adults. Townes [(1938) (16)] reports that many species of *Ichneumon* were found hibernating in November in Massachusetts, among them [*Melanichneumon*] *Ichneumon rubicundus*. This, in itself, is not sufficient evidence that the species can survive the whole winter.

Attempts to hold *M. rubicundus* adults in cold storage for long periods were not successful, the greatest survival being about sixty days, which is not as long as adults remained alive in the laboratory at a day temperature of 75°F. and a night temperature of 50°F. For *P. nigridens* Smith (14) reports a maximum life under insectary conditions of 110 days. The present author had a single *P. nigridens* female which remained alive and active for five months at laboratory temperatures, 75°F. day and 50°F. night.

Smith (10c. cit.) found that *P. nigridens* larvae could not withstand temperatures below 53.6°F. for as much as four weeks. The results of some tests on the ability of *M. rubicundus* larvae to survive sub-developmental temperatures are shown in Table 7. It will be noted that the highest survival for a relatively long period (99 days) occurred in parasitized material placed in cold storage after two days incubation or when the parasite larvae were still in the first stage.

Table 7. Storage of *M. rubicundus* at various periods of development.

Days incubation at 75°F. after parasitism	Time in storage at 45°F.	No. parasitized	Days incubation at 75°F. after storage: To 1st emerg.	To last emerg.	♂ ♂	♀ ♀	Per cent
0	101 da.	23	13 da.	20 do.	4	5	39.1
2	99 da.	20	11 da.	19 da.	7	7	70.0
3	73 da.	36	12 da.	18 da.	17	7	66.6
4	77 da.	34	9 da.	18 da.	7	6	38.2
5	68 da.	24	9 da.	11 da.	5	2	29.1
5	54 da.	28	8 da.	13 da.	12	2	50.0
7	33 da.	25	8 da.	11 da.	3	3	24.0
8	29 da.	17	7 da.	8 da.		3	17.6
9	33 da.	30	6 da.	7 da.	8		26.6
10	26 da.	16	5 da.	7 da.	9	2	58.7

It would be expected that species, of which the fall emerging females hibernate, would not be prepared to deposit eggs very shortly after emergence. As stated earlier the preoviposition period of *M. rubicundus* is from one to fourteen days with the bulk of the females being ready to oviposit less than five days after emergence. The preoviposition period of *P. nigridens* on the other hand is eleven days to twelve weeks (Smith) (loc. cit.).

Lacking exact data on the hibernation of a species as adults the following factors might be considered in assessing the possibility of such occurring; (1) longevity of adults, those capable of long adult life might be capable of hibernation, (2) length of preoviposition period, having eggs ready to deposit shortly after emergence would not be an advantage where a parasite was going to hibernate, (3) ability of larvae to survive long periods at sub-developmental temperatures, indicating a possibility of hibernation in the immature stages rather than as adults. In Table 8 a comparison is made between *P. nigridens* and *M. rubicundus* considering these three factors.

Table 8. Comparison of factors related to hibernation of *P. nigridens* and *M. rubicundus*.

	Phaeogenes nigridens	*Melanichneumon rubicundus*
Hibernation of adults	Definitely established	Not definitely established
Observed longevity of adults in the laboratory	5 months	74 days
Preoviposition period	11 days to 12 weeks	1 - 14 days
Survival of immature stages at less than developmental temp.	4 weeks	99 days

It would appear that *P. nigridens* gives every indication of being well suited to hibernate as an adult while in the three factors considered *M. rubicundus* is less well suited.

The data given were obtained from material bred on *L. sticticalis* which can be presumed to be an unnatural host. The fact that the greatest survival in storage occurred in first stage larvae might indicate that the parasite could spend the winter in this stage. *L. sticticalis* does not hibernate as a pupa hence has no diapause tendency in this stage and it would appear that the only factor inhibiting the development of the larvae in these pupae would be the low temperature. There is a possibility that *M. rubicundus* larvae in lepidopterous pupae which winter as pupae would be arrested in the first stage by the diapause tendency of the host and would pass the winter successfully in such hosts. Until further evidence is secured the matter will be in doubt.

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LITERATURE CITED

1. Beirne, B. P. — 1941. A consideration of the cephalic structures and spiracles of the final instar larvae of the Ichneumonidae (Hym.). Trans. Soc. Br. Ent. 7:Pt. 5.
2. Breakey, E. P. — 1931. Additional notes on the natural enemies of the iris borer, *Macronoctua onusta* Grote (Lepid.). Ann. Ent. Soc. Amer. 24:43.
3. Clausen, C. P.—1940. Entomophagus Insects. New York.
4. Cresson, E. T. — 1864. Descriptions of North American Hymenoptera in the collections of the Ent. Soc. of Philadelphia. Proc. Ent. Soc. Phil. 3.
5. Cresson, E. T. — 1877. Notes on the species belonging to the subfamily Ichneumonides found in North America, North of Mexico. Trans. Am. Ent. Soc. 6:129-212.
6. Fiske, W. F. — 1910. Superparasitism: an important factor in the natural control of insects. J. Econ. Ent. 3:88-97.
7. Imms, A. D.—1931. Recent Advances in Entomology. London.
8. Norton, Edward — 1869. Catalogue of the described Tenthredinidae and Urocevidae of North America. Trans. Am. Ent. Soc. 2:321.
9. Packard, C. M. — 1916. Life histories and methods of rearing Hessian-fly parasites. Agr. Res. 6, 10:367-381.
10. Pampel, W. — 1914. Die Weiblischen Geschlechtsorgne der Ichneumoniden. Ztschr. Wiss. Zool. 108:290-357.
11. Seurat, L. G. — 1899. Contributions a L'étude des Hyménoptères entomophages. These, Faculte des Sciences de Paris.
12. Seyrig, A. — 1924. Observations sur la biologie des Ichneumons. Soc. Ent. de France Ann. 92:345-362.
13. Simmonds, F. J. — 1947. Improvement of the sex-ratio of a parasite by selection. Can. Ent. 79:41-44.
14. Smith, H. D. — 1932. *Phaeogenes nigridens* Wesmael, an important ichneumonid parasite of the pupa of the European Corn Borer, U. S. Dept. Agr. Tech. Bull. 331.
15. Snodgrass, R. E.—1935. The principles of Insect Morphology. New York.
16. Townes, H. K. — 1938. Ichneumon hibernation in the Northeastern United States. (Hymenoptera, Ichneumonidae). Ent. News. 49:219-221.
17. Townes, H. K. — 1944. A catalogue and classification of the nearctic Ichneumonidae. Mem. Am. Ent. Soc. 11, Pt. 1: Acad. Nat. Sc. Phil.
18. Vance, A. M. and H. D. Smith — 1933. The larval head of the parasitic Hymenoptera and nomenclature of its parts. Ann. Ent. Soc. Amer. 26:86-94.
19. Wishart, George — 1945. *Aplomya caesar* (Aldrich), a tachinid parasite of the European Corn Borer. Can. Ent. 77, 157-167.

EXPLANATION OF SYMBOLS USED IN THE ILLUSTRATIONS

ACGL — acid gland
AED — aedeagus
ALGL — alkali gland
ANT — antenna
ANTR — antennal rudiment
ATRC — anterior tracheal commisure
ATR — atrium
CA — closing apparatus
CLY — clypeus
CON — condyle
DIGTR — digestive tract
EP — epistoma
FR — frons
FS — frontal suture
HYP — hypostoma
IMDS — inferior mandibular support
LAS — labiostipal sclerome
LBP — labial palpus
LM — labrum
MAS — maxillary sclerome
MAX — maxilla
MD — mandible
MS — metoptic suture
MTR — main tracheal trunk
NC — nutritive cells
OC — oocyte
OD — oviduct
OV — ovary
PL — pleurostoma
PS — poison sac
SCR — scrotum
SKDO — silk duct opening
SMDS — superior mandibular support
SOR — sensory organs
SL — slit for holding pupa
SP — spiracle
SPM — spermatheca
STP — spiracular stumps
STR — secondary tracheal trunk
TEFL — terminal filament
TER — terebra
TES — testis
TR — trachea
VD — vas deferens
VS — vesiscula seminalis

NOTES ON THE INSECT PARASITES OF THE SPRUCE BUDWORM[1] *CHORISTONEURA FUMIFERANA* (CLEM.) IN BRITISH COLUMBIA.

by

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Running title — Wilkes, Coppel, Mathers — Parasites of Spruce Budworm.

INTRODUCTION

The spruce budworm, *Choristoneura* (*Archips*) *fumiferana* (Clem.) (Tortricidae) has long been considered one of the most injurious forest insect pests in Canada. A general account of past outbreaks and an outline of its biology and habits are given by Swaine and Craighead (1924). At the time these studies were made investigations were also undertaken by J. D. Tothill and A. B. Baird on the parasites and other natural control factors of the spruce budworm, but although a good deal of work was done, brief reference to which is made by Hewitt (1911, 1912, 1913), very little has been published.

During the present outbreak, interest in this work has been revived and as part of the general control programme of studies an attempt has been made by the Dominion Parasite Laboratory, in co-operation with the Forest Insects Unit, to establish in Eastern Canada parasites found by Tothill (1923) and Baird to be present only in certain areas of British Columbia. During the course of this work large collections of budworm have been made and reared for the recovery of parasites. A report on the progress of the work and the number of parasites released in Eastern Canada to 1946 has been given by Wilkes (1946). In addition to the parasite species selected for liberation many others were reared from the collections. Over 45 species have been reared, many of which have not previously been recorded as parasites of this host.

Since the inception of the present study a great deal of data has accumulated on the general parasite complex of *C. fumiferana* and although the work is being continued, it is considered advisable to put on record some of the findings made to date. This paper is, therefore, a summary of the preliminary aspects of the work and is presented largely with a view to bringing together all previously published records of insect parasites attacking this species in North America and to add records of other parasites reared from collections made during the present investigation. Further studies of the biology of the more important parasites with particular reference to alternate hosts and the inter-relations of some of the species among the large parasite complex found attacking *C. fumiferana* are being continued with considerable interest.

In carrying out the work involved in this study a great deal of credit is due to a number of individuals and organizations without whose help its success would not have been possible. We should like to express our gratitude particularly to Dr. C. D. Orchard, Deputy Minister of the British Columbia Department of Forests, and to his officers at Kamloops, Lytton and Lillooet, B.C.; also to the British Columbia Security Commission for their active help in connection with the field studies. We are also grateful for the taxonomic assistance given by Messrs. Walley, Peck and Brooks of the Systematic Unit at Ottawa.

PREVIOUS RECORDS OF PARASITES REARED FROM *C. FUMIFERANA*

Extensive insect parasitism of *C. fumiferana* has been noted by a number of observers in Canada and the United States. From an examination of the literature 44 species have been recorded. These records, however, give little precise information as to the importance of many of the species or of the interrelationships of the parasites. In the case of many of them the exactness of the records

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is somewhat questionable and in most cases their rôle as control factors is unknown. Of the 44 recorded parasites only 31 were referred to by species, the remainder were determined only to the genus. In only one of all the species recorded was reference made to their status as primary or secondary parasites of this host. A list of species previously recorded as parasites of *C. fumiferana* is given below with the authority and reference citation in brackets. In listing the Ichneumonidae the nomenclature and arrangement of the Townes' catalogue (1944) has been followed throughout.

HYMENOPTERA

Ichneumonidae.

Ichneumoninae:

Coccygomimus pedalis (Cress.), [Forbush and Fernald, 1896; Fiske, 1903; Cushman, 1920a; Wilkes and Anderson, 1947], *Ephialtes* of Cushman.

**Coccygomimus sanguineipes* (Cress.). [Bedard, 1938], *Ephialtes* of Bedard, (*vide* Townes, 1944).

Ephialtes ontario (Cress.), [Johannsen, 1913; Cushman, 1920a; Johnson, 1927; Brown, 1941; Coppel, 1947; Wilkes and Anderson, 1947], *Pimpla* of Johannsen, *Apechthis* of Brown, Cushman and Johnson, (*vide* Townes, 1944).

**Iseropus coelebs* (Walsh), [Johnson, 1927].

**Itoplectis atrocoxalis* (Cress.), [Bedard, 1938].

Itoplectis conquisitor (Say), [Johannsen, 1913; Cushman, 1920a; Twinn, 1938; Brown, 1941; Wilkes and Anderson, 1947], *Ephialtes* of Cushman and Twinn, *Pimpla* of Johannsen, (*vide* Townes, 1944).

Itoplectis obesus Cush., [Cushman, 1920a; Tothill, 1923; Mathers, 1932; Coppel, 1947], *Ephialtes* of Cushman and Mathers, (*vide* Townes, 1944), *Itoplectis* sp. of Tothill.

**Itoplectis quadricingulatus* (Prov.), [Bedard, 1938]. Referred to by Bedard as *I. esuchus* and synonymized with *I. quadricingulatus* by Townes (1944).

**Scambus atrocoxalis* (Ashm.), [Bedard, 1938], *Epiurus atrocoxalis* of Bedard, (*vide* Townes, 1944).

Scambus hispae (Harr.), [Viereck, 1912; Hewitt, 1913; Mathers, 1932; Coppel, 1947; Wilkes and Anderson, 1947], *Epiurus innominatus* Vier. of Hewitt and Mathers, (*vide* Townes 1944), *S. indagator* of Wilkes and Anderson.

**Scambus* probably *alboricta* (Cress.), [Wilkes and Anderson, 1947].

**Scambus* sp., [Wilkes and Anderson, 1947].

Theronia atalantae (Poda), [Cushman, 1920b], *T. fulvescens fulvescens* (Cress.) of Cushman (*vide* Townes, 1944).

Tryphoninae:

Phytodietus fumiferanae Rohw., [Rohwer, 1922; Tothill, 1923; Mathers, 1932; Wilkes, 1946; Coppel, 1947; Wilkes and Anderson, 1947], *Phytodietus* sp. of Tothill.

tes of Cushman.

Cryptinae:

Gelis tenellus (Say), [Wilkes and Anderson, 1947].

Phaeogeninae:

Phaeogenes hariolus (Cress.), [Viereck, 1912; Hewitt, 1913; Tothill, 1923; Bedard, 1938; Brown, 1941; Lambert, 1942; Coppel, 1947; Wilkes and Anderson, 1947], *Herpestomus* of Bedard, *Phygadeuon*

plesius Vier. of Hewitt and *Phygadeuon* sp. of Tothill, (*vide* Townes, 1944).

Lissonotinae:

Glypta fumiferanae (Vier.), [Viereck, 1912; Hewitt, 1913; Tothill, 1923; Bedard, 1938; Brown, 1941 and 1946b; Mills, 1942; Coppel, 1947; Wilkes and Anderson, 1947]; *Conoblasta* of Hewitt, *Glypta* sp. of Tothill, (*vide* Townes, 1944).

**Pimplopterus* sp., [Wilkes and Anderson, 1947].

Ophioninae:

**Horogenes* sp. [Coppel, 1947].

Mesochorinae:

**Mesochorus diversicolor* (Vier)., [Viereck, 1912; Hewitt, 1913].

Braconidae:

Apanteles fumiferanae (Vier)., [Hewitt, 1912 and 1913; Gibson, 1912; Viereck, 1912; Johannsen, 1913; Treherne, 1915; Muesebeck, 1920; Tothill, 1923; Brown, 1946a; Coppel, 1947; Wilkes and Anderson, 1947], *Apanteles* sp. of Johannsen and Tothill.

**Ascogaster* sp., [Brown, 1941].

Bracon probably *politiventris* (Cush.), [Wilkes and Anderson, 1947].

**Bracon* sp., [Coppel, 1947].

Meteorus trachynotus Vier., [Viereck, 1912; Tothill 1923; Muesebeck, 1923; Brown, 1941; Wilkes and Anderson, 1947], *Meteorus* sp. of Tothill.

**Microgaster* sp., [Mills, 1942; Wilkes and Anderson, 1947].

**Rogas* sp., [Wilkes and Anderson, 1947].

Chalcididae.

Pteromalinae:

Amblymerus verditer (Nort.), [Gibson, 1910; Hewitt, 1911; Treherne, 1915; Tothill, 1923; Brown, 1941; Coppel, 1947], *Nasonia tortricis* Brues of Gibson, Hewitt and Treherne, *Nasonia* sp. of Tothill.

**Amblymerus* sp., [Brown, 1941].

**Hypopteromalus* sp., [Brown, 1941].

Encyrtinae:

**Copidosoma* sp. [Wilkes and Anderson, 1947].

**Encyrtinae*, [Wilkes and Anderson, 1947].

Eulophinae:

**Eulophus* sp., [Brown, 1941].

Trichogramminae:

Trichogramma minutum Rly., [Hewitt, 1912 and 1913; Tothill, 1923; Treherne, 1915; Bedard, 1938; Wilkes and Anderson, 1947], *Pentarthron* of Hewitt and Treherne, (*vide* Girault, 1911).

DIPTERA:

Sarcophagidae.

Pseudosarcophaga affinis (Fall.), [Wilkes, 1946; Coppel, 1947].

Sarcophaga sp., [Brown, 1941].

Tachinidae.

Aplomya caesar (Ald.), [Tothill, 1913; Brown, 1941; Wilkes and Anderson, 1947], *Exorista nigripalpis* Tns. of Tothill, *Zenillia caesar* of Brown, (*vide* Sellers, 1943).

Ceromasia auricaudata Tns., [Tothill, 1913; Wilkes, 1946; Coppel, 1947], *Masicera rutila* Meig. of Tothill (*vide* Brooks, 1945).

Gymnophthalma interrupta (Curr.), [Brown, 1941], *Actia*, of Brown, (*vide* Townsend, 1940).

Lypha setifacies (West.), [Brown, 1941; Brooks, 1945; Coppel, 1947; Wilkes and Anderson, 1947]; *L. dubia* Fall. of Brown, (*vide* Brooks, 1945).

Nemorilla pyste (Wlk.), [Tothill, 1913; Bedard, 1938; Brown, 1941], *N. floralis* (Fall.) of Bedard, *N. maculosa* Mg. of Brown and *Exorista pyste* of Tothill.

Omotoma fumiferanae (Tot.), [Hewitt, 1913; Tothill, 1912, 1913 and 1923; Brown, 1941; Coppel,, 1947; Wilkes and Anderson, 1947], *Winthemia* of Brown, Hewitt and Tothill, (*vide* Townsend, 1940).

Phorocera incrassata Smith, [Wilkes, 1946; Coppel, 1947].

Phryxe pecosensis (Tns.), [Tothill, 1913; Johannsen, 1913; Brown, 1941; Wilkes and Anderson, 1947], *Zenillia vulgaris* Fall. of Brown, *Exorista vulgaris* Fall. of Johannsen and Tothill, (*vide* Sellers, 1943).

*Species *not* reared from *C. fumiferanae* in the present study.

SITE OF THE PRESENT INVESTIGATIONS

In 1943, a preliminary survey was undertaken with the co-operation of members of the staff of the Forest Insects Laboratory, Vernon, B.C., in an attempt to locate suitable areas for the collection of spruce budworm parasites for transfer to Eastern Canada. Areas covered in the survey included Vancouver Island and a number of points in the central part of the mainland of British Columbia. Although spruce budworm was not found to be especially abundant in any of the areas examined, in almost all the collections made in the wooded section of the Fraser Valley, particularly near Lillooet, three species of parasites were found which had not been previously recorded in the east.

In view of the relatively greater abundance of the budworm at Lillooet and the immediately surrounding areas and the unusual accessibility of the terrain, the collecting work was confined largely to this general locality. In 1943, small collections of budworm were made on Mt. McLean, near Lillooet, and on Mission Mountain, near Shalalth.

In 1944 large-scale collections were made, mainly on Mt. McLean, Mission Mountain and on the mountain range near McGillivray Falls. During the summer of 1945, large-scale collections were made only on McLean and Mission Mountains, in 1946 on Mt. McLean and at Texas Creek and in 1947 at Mt. McLean, Texas Creek and Fountain Valley. The location of the collecting points is shown in figure 1. In all the areas, collecting could be carried out only along a somewhat narrow band on the wooded slopes of the mountains from approximately the 1000 to 3700 foot elevation. This band is referred to by Glendenning (1921) as comprising the Arid Transition Zone (1000 to 1700 ft.) and the Humid Transition Zone (1700 to 3700 ft.) of Merriam.

In addition to the sites selected for large-scale collecting, other areas in neighbouring budworm infestations were examined and collections made whereever posible for parasite rearing. The results obtained at two of these points are included in the present paper. One was located at Texas Creek on the mountain slope east of the Fraser river, seven miles north of Lillooet, and the other was in Fountain Valley about five miles northwest of Lillooet.

METHODS OF COLLECTING

The general methods and equipment used in the collecting and rearing of the budworm and its parasites have been essentially the same as described in a previous paper by Wilkes (1946). During the 1946 season some changes were made in the method used for removing the budworm larvae from the trees, and in the use of large cloth mats spread on the ground below the trees. An outline of the technique used that year has been given by Coppel (1946).

In addition to the large-scale collections made each day throughout the peak period of budworm development in the field for transfer of the parasites to Eastern Canada, special collections were made in order to obtain more precise information on the number of species and their abundance in the various localities. These collections were made at regular seven-day intervals, beginning at about the third stage of larval development and were continued until the moths began to emerge. The most complete records of this type were obtained at McLean and Mission Mountains. In these areas the special collections were made on the same day at each of three elevations, i.e. 1000, 2000 and 3000 feet. Each collection was then segregated into two groups representing those collected as larvae and those collected as pupae. Approximately ten per cent. of each collection was placed directly into preserving fluid and set aside for dissection. These were used to obtain immature stages of the parasites and to provide additional information on the abundance of the various species. The remainder were placed individually into vials and reared for parasite emergence at a temporary field laboratory set up for this purpose at Lillooet. All the adult emergents were pinned and recorded on special emergence cards. At the end of the season the remainder of the collections were transferred to Belleville where incubation was completed and the parasites were identified.

PARASITES REARED DURING THE PRESENT STUDY

During the course of the present work 45 species of parasites and one predator were reared from the collections of *C. fumiferana*. It will be noted in the list given below that 18 species recorded here have not been previously reported while 19 of the species previously recorded were not reared from budworm in the present study. Eleven of the latter species, *Iseropus coelebs*, reported from Maine by Johnson (1927), *Ascogaster* sp., *Hypopteromalus* sp., *Amblymerus* sp., and *Eulophus* sp. recorded by Brown (1941) from the Forest Insect Survey in Eastern Canada and *Scambus alboricta, Scambus* sp., *Pimplopterus* sp., *Rogas* sp., *Copidosoma* sp., and *Encyrtinae* sp., reported by Wilkes and Anderson, (1947), were recorded from budworm collected in the east and it is, therefore, possible that localities covered in this study do not come within the area of their present distribution. This may also be true of five other species, *Itoplectis atrocoxalis, Itoplectis quadricingulatis, Coccygomimus sanguineipes* and *Scambus atrocoxalis* reported by Bedard (1938) from Idaho and *Microgaster* sp. reported by Mills (1942) from Montana, although in these cases the distances involved are not nearly so great. It is quite likely that the *Itoplectis* sp. recorded from B.C. by Tothill (1923) is the same as *Itoplectis obesus* listed in the present work. On the other hand, *Mesochorus diversicolor* reported as being recovered from *C. fumiferanae* collected in Quebec and British Columbia by Hewitt (1913) was not reared from this host during the present study in British Columbia. The representatives of the two genera, *Horogenes* and *Bracon* from B.C. referred to by Coppel (1946) are in all probability the same as the two species *H. cacoeciae* and *Bracon* near *politiventris* listed in the present work.

The following is a list of the parasites reared from *C. fumiferana* during the present study. Where it is known, reference is made to the status of the parasites, i.e. whether primary (P) or hyperparasite (H), and the stage of the host attacked in the case of the primary species.

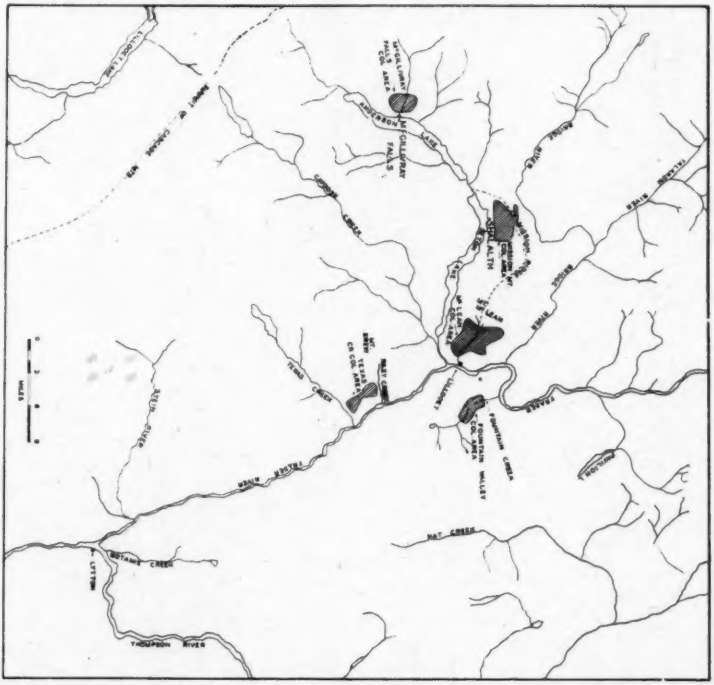

FIGURE 1. Location of the budworm collecting points in the Lillooet area of B.C.

HYMENOPTERA	Status	Stage attacked
Ichneumonidae.		
Ichneumoninae:		
Coccygomimus pedalis (Cress.)	P.	Pupae
Ephialtes ontario (Cress.)	P.	Pupae
Itoplectis conquisitor (Say)	P.	Pupae
Itoplectis obesus Cush. Occasionally hyperparasitic on *Phytodietus fumiferanae*	P.	Pupae
Scambus hispae (Harr.) Ex. *Glypta* and *Phytodietus*	P. and H.	Larvae
Theronia atalantae (Poda)	P.	
Tryphoninae:		
Phytodietus fumiferanae Rohw.	P.	Late Larvae
Cryptinae:		
Gelis tenellus (Say)	H.	
**Otacustes crassus crassus* (Prov.)		
Phaeogeninae:		
**Amblyteles* sp.		
Phaeogenes hariolus (Cress.)	P.	Early stage pupae.
**Pterocormus audax* (Cress.)		
**Pterocormus audax* (Cress.)		
Lissonotinae:		
Glypta fumiferanae (Vier.)	P.	1st and 2nd stage larvae
Mesoleiinae:		
**Euceros* probably *thoracicus* (Cress.) ex *Phytodietus* sp.	H.	
Metopiinae.		
**Exochus* sp.		
Ophioninae:		
**Campoplex* probably *validus* (Cress.)		
Horogenes cacoeciae (Vier.)	P.	1st and 2nd stage larvae
**Labrorychus* sp.		
Mesochorinae:		
Mesochorus sp. Ex *Glypta, Phytodietus* and *Apanteles.*	H.	
Braconidae.		
Apanteles fumiferanae Vier.	P.	1st and 2nd stage larvae
Bracon near *politiventris* (Cush.)	P.	Larvae
**Meteorus hyphantriae* Rly.	P.	
Meteorus trachynotus Vier.	P.	4th stage larvae
Chalcididae.		
Chalcidinae:		
Spilochalcis sp. Ex *Glypta* and *Apanteles*	H.	
Toryminae:		
**Monodontomerus montivagus* Ashm.		
**Monodontomerus* probably *subobsoletus* Gahan		

Pteromalinae:		
Amblymerus verditer (Nort.) Ex *Phytodietus*	H.	
**Habrocytus phycidis* Ashm.		
Eulophinae:		
**Tetrastichus* sp.		
Trichogramminae:		
Trichogramma minutum Rly.	P.	Egg
DIPTERA		
Tachinidae.		
Aplomya caesar (Ald.)	P.	Larvae
Ceromasia auricaudata Tns.	P.	Larvae
Gymnophthalma interrupta (Curr.)	P.	Larvae
Lypha setifacies (West.)	P.	Larvae
**Madremyia saundersii* (Will.)	P.	Larvae
Nemorilla pyste (Wlk.)	P.	Larvae
Omotoma fumiferanae (Tot.)	P.	Larvae
**Phorocera erecta* Coq.	P.	Larvae and early stage pupae
Phorocera incrassata Smith	P.	Larvae
**Phorocera tortricis* Coq.	P.	
Phryxe pecosensis (Tns.)	P.	Larvae
Sarcophagidae.		
Pseudosarcophaga affinis (Fall.)	P.	Larvae and pupae
Sarcophaga sp.		
Phoridae.		
**Megaselia* sp.		
Muscidae.		
**Muscina stabulans* Fall. Probably a scavenger on late larvae and pupae.		
COLEOPTERA		
Cleridae.		
**Hydnocera lecontei* Wolc. Predator on late larvae.		

*Not previously recorded as parasites or predators of *C. fumiferana.*

RELATIVE ABUNDANCE OF THE PARASITES

On the basis of the work done up to the present it is somewhat hazardous to attempt to present statistics on the degree of parasitism by the different parasite species. In order to give reliable values in conventional terms of percentage parasitism observations must be made over a long period of time and from a large number of collections gathered at all stages during the development of the host in the field. This is particularly true in the case of *C. fumiferana.* In addition, rearing this species in the laboratory is a relatively difficult matter. Mortality is usually high, thus introducing another factor of uncertainty. More precise information on parasitism might be obtained by dissection of the hosts soon after the collections are made. At the present time, however, very little is known regarding the life-history of many of the parasites and therefore the various species cannot be identified with any degree of certainty by an examination of the immature stages. In view of these considerations the statistics on parasitism cannot be regarded as absolute values and indeed it must be kept in mind that in some cases they may be somewhat misleading.

In view of these qualifying reservations the abundance of the parasites as presented here can only be taken as an approximate guide to the numerical status of the parasites in the field, except in one area at Mt. McLean, where the study was carried out for a longer period and in considerably more detail than at other points. In most of the areas under study the work was conducted each season for a number of years and in some, the seasonal collections amounted to almost 500,000 individuals. Nevertheless, only a small proportion of the total number collected was taken over the entire period of budworm development. In view of these differences in methods of collecting the records of parasitism as shown in tables 1 and 2 are listed under two headings. In one, referred to as "special collections", the budworms were gathered at seven-day intervals beginning at the third stage of larval development and continued throughout the full period of development in the field. The other, referred to as "mass collections", was gathered largely during the late larval and pupal stages and, for the most part, when the population of these stages was at a maximum. The mass collections provided material for the large-scale transfer of certain species of parasites to Eastern Canada (*vide* Wilkes 1946). Thus, the special collections although they provide reliable data on the species attacking all stages of the budworm, are somewhat small in number, while the mass collections are numerically large but do not include some of the parasite species which emerge from the budworm during its earlier larval stages of development. Throughout the work considerable care was exercised in the identification of the host insects collected and therefore the parasites which emerged after rearing provide a definite record of the species parasitizing *C. fumiferana* in the areas under study.

An indication of the extent of parasitism and a list of the species involved in regulating the abundance of *C. fumiferana* in the Lillooet area of British Columbia may be obtained by an examination of the records shown in table 1 and 2. In both tables the degree of parasitism is calculated as a percentage of the total number of budworm placed in rearing. Whether or not an equal proportion of parasitized and unparasitized budworm died in rearing is unknown. It is assumed in the present study that mortality was the same in both. These provide an approximate measure of the percentages of the pest that are destroyed by each of the parasite species with the exception of the parasites attacking the eggs.

During 1946 and 1947 a number of collections of *C. fumiferana* egg-clusters was made and reared for the purpose of determining the importance of egg parasites. These consisted of three collections made on Mt. McLean in 1946 and 1947 and one in Fountain Valley in 1947. In each case the eggs were taken from trees selected at random throughout the infestations. From these the only parasite reared was the chalcid, *Trichogramma minutum* Rly. The degree of parasitism by this species is shown in table 3.

Table 3. *Trichogramma minutum* reared from *C. fumiferana* collected at Mt. McLean and Fountain Valley, B.C.

Locality	Year	Number of egg-clusters reared	Number of egg-clusters parasitized	Percentage of egg-clusters parasitized	Percentage of eggs parasitized
Mt. McLean	1946	2000	12	0.60	0.03
Mt. McLean	1947	395	43	10.89	0.99
Fountain Valley	1947	1617	13	0.80	0.42

It will be noted in the table that parasitism of *C. fumiferana* eggs in both the areas under study was quite low.

Table 1. Parasites reared from *C. fumiferana* collected at Mt. McLean, B.C. Parasitism is shown as the percentage number of each species reared from the total number of budworm placed into incubation each year.

	Special Collections					Relative abudance	Mass Collections			
	1943	1944	1945	1946	1947	1943-1947	1944	1945	1946	1947
Number of budworm reared	3332	912	6686	4217	2678		78700	103526	358890	166539
HYMENOPTERA										
Ichneumonidae										
Campoplex sp.			.03			.03				.002
Coccygomimus pedalis							.001		.0006	
Ephialtes ontario	.88	6.69	.51	.47	1.20	1.95	1.05	.47	.16	.77
Euceros probably *thoracicus*									.001	
Exochus sp.	.03					.03				
Gelis tenellus	.03					.03				
Glypta fumiferanae	1.45	7.23	7.34	2.06	7.84	5.18	12.85			
Horogenes cacoeciae							.001			
Itoplectis conquisitor							.02			
Itoplectis obesus	.34	.33	.72	.12	.11	.32	.16	.06	.04	.29
Labrorychus sp			.02			.03		.001	.0003	
Mesochorus sp.			.08			.08				
Otacustes crassus crassus	.03					.03				
Phaeogenes hariolus	.06	1.75	.81	.55	.37	.70	.09	.30	.02	.01
Phytodietus fumiferanae	10.65	3.18	1.58	2.80	.97	3.83	5.19	3.92		
Pterocormus audax								.003	.0008	
Scambus hispae	.03		.46			.09			.0006	.0006
Theronia atalantae							.001		.003	
Braconidae										
Apanteles fumiferanae		.44	1.49	.07	1.16	.79	.06			

	Special Collections					Relative abudance	Mass Collections			
	1943	1944	1945	1946	1947	1943-1947	1944	1945	1946	1947
Meteorus hyphantriae	.03					.03				
Microbracon near *politiventris*					.04	.04				
Chalcididae										
Amblymerus verditer			.57	.47	.42	.49	.01	.001	;007	
Habrocytus phycidis					.11	.11	.001			
Monodontomerus montivagus						.	.001			
Monodontomerus probably *subobsoletus*						.	.001			
Tetrastichus sp.				.14		.14				
Undetermined hymenopterous larvae				.29	.14	.21				
DIPTERA										
Tachinidae										
Aplomya caesar	.03	.11	.24	.07	.07	.10	.10	.08	.06	.06
Ceromasia auricaudata	.19	.66	1.58	3.75	4.14	2.06	8.65	4.62	1.73	4.68
Gymnophthalma interrupta								.001	.001	.003
Lypha setifacies			1.88	.85	1.23	1.32		3.58	2.63	3.56
Madremyia saundersii	.03	.22	.09	.71	2.20	.65	.44	.38	.58	2.67
Nemorilla pyste								.005	.001	.01
Omotoma fumiferanae		1.86	3.14	2.92	1.72	2.41	.89	6.48	3.43	3.38
Phorocera erecta	.47	.66	.13	.05		.33	1.78	.05	.03	.02
Phorocera incrassata	.94	1.54	.18	.07	1.68	1.10	.05	.04	.02	.50
Phorocera tortricis									.0003	.001
Phryxe pecosensis	.09	.88	.04	.33	.04	.27	.11	.06	.19	.24
Sarcophagidae										
Pseudosarcophaga affinis			.77	.12	3.99	1.63	3.07	.81	2.01	1.26
Sarcophaga sp.							.01			.0006
Undetermined sarcophagid larvae				2.42		2.42				
Muscidae										
Muscina stabulans								.03		.003
Undetermined Diptera				.07	.09	.08				
Total parasitism	15.28	25.55	21.67	18.33	27.52	26.48	33.53	20.89	10.91	17.46

Table 2. Parasites reared from *C. fumiferana* collected at Mission Mountain, Texas Creek, MacGillivray Falls and Fountain Valley. Parasitism was calculated in the same manner as in Table 1.

	Mission Mountain					Texas Creek			MacGillivray Falls	Fountain Valley
	Special collections			Mass collections		Special	Mass	Mass	Mass	Mass
	1943	1944	1945	1944	1945	1946	1946	1947	1944	1947
Number of budworm reared	1337	821	5189	114500	150689	481	25821	18557	29900	402170
HYMENOPTERA										
Ichneumonidae										
Amblyteles sp.				0.002	0.001					
Coccygomimus pedalis				0.003						0.0002
Ephialtes ontario	0.60	1.58	0.23	2.47	0.15	0.21	0.19	2.23	1.47	0.55
Exochus sp.										0.0004
Gelis tenellus				0.001					.02	
Glypta fumiferanae	5.40	7.92	6.82			1.25			3.86	
Horogenes cacoeciae			0.06							
Itoplectis conquisitor				0.01					0.01	
Itoplectis obesus	0.50		0.25	0.07	0.03	0.62	0.15	0.75	0.18	0.04
Labrorychus sp.			0.02							
Mesochorus sp			0.02							
Phaeogenes hariolus		0.12	0.10	0.04	0.03		0.01	0.22	0 15	.0.09
Phytodietus fumiferanae	0.30	1.83	3.23	1.32	3.46	6.03	5.08		4.80	
Pterocormus audax					0.001					0.0002
Scambus hispae			0.10	0.001					0.007	0.06
Theronia atalantae				0.001						0.003
Braconidae										
Apanteles fumiferanae	0.10	0.36	1.73						0.50	0.61
Meteorus trachynotus			0.02							
Microbracon near *politiventris*							0.01			

	Mission Mountain					Texas Creek			McGillivray Falls	Fountain Valley
	Special collections			Mass collections		Special	Mass	Mass	Mass	Mass
	1943	1944	1945 MacGillivray	1944	1945	1946	1946	1947	1944	1947
Chalcididae										
Amblymerus verditer			0.08				0.01		0.02	0.07
Habrocytus phycidis				0.002						0.001
Spilochalcis sp.			0.02							
Undetermined hymenopterous larvae						0.21				
DIPTERA										
Tachinidae										
Aplomya caesar		0.24	0.17	0.60	0.06		0.02	0.05	0.03	0.003
Ceromasia auricaudata	9.30	9.50	0.65	13.06	2.30	8.73	1.94	10.42	6.61	1.09
Gymnophthalma interrupta								0.02		0.002
Lypha setifacies			2.44	0.02	10.14	0.21	0.28	0.03		0.04
Madremyia saundersii	0.07	0.24	0.02	0.50	0.13	0.42	0.54	1.15	0.03	0.09
Nemorilla pyste				0.01	0.01			0.02		0.002
Omotoma fumiferanae		5.12	6.16	5.50	13.55	2.29	3.39	1.70	14.86	1.63
Phorocera erecta	0.07		0.13	0.37	0.11	0.21		0.005	0.82	0.003
Phorocera incrassata	0.60	0.73	0.02	0.06	0.08		0.02	0.35	0.16	0.07
Phryxe pecosensis		0.24		0.36	0.05	0.42	0.60	0.06	0.19	0.02
Sarcophagidae										
Pseudosarcophaga affinis			0.08	1.58	0.24		1.02	1.37	3.43	6.15
Sarcophaga sp.				0.02						0.02
Undetermined sarcophagid larvae						3.12				
Phoridae										
Megaselia sp.					0.001					
Muscidae										
Muscina stabulans					0.001					0.08
Undetermined Diptera						0.21				
COLEOPTERA										
Cleridae										
Hydnocera lecontei			0.08							
Total Parasitism	7.94	27.88	22.43	29.00	30.344	23.93	16.26	18.375	37.147	10.624

Although complete records on the number of eggs in each cluster and the number of eggs parasitized could not be made, representative samples from each collection were examined in detail and from these it was found that less than 1 per cent of the eggs were parasitized by *T. minutum*. Even at Mt. McLean in 1947 where almost 11 per cent of the egg clusters were parasitized, on the average only 52.3 per cent of the eggs in the clusters were attacked. The number of eggs per egg-cluster varied from 10 to 80 with a mean of 35. The average number of parasites per egg-cluster was 47.5 and the sex-ratio was 80.4 per cent females. Thus it was calculated that an average of 2.1 parasites were produced per parasitized egg. This low degree of parasitism is somewhat surprising in view of Hewitt's (1912) record of 43 per cent egg parasitism at Esquimault, B.C. in 1911.

The extent of parasitism in the other stages of development (larvae and pupae) may be seen in tables 1 and 2. Of the 45 species of parasites listed, however, only 27 were found from the rearing records obtained in the present study to be primary on *C. fumiferana*, 7 were known to be hyperparasites and the rôle of 11 is as yet unknown. This is shown in tabulated form in table 4. The last group is relatively unimportant from the standpoint of control since only a few specimens were taken, often not more than one individual of a species, even from the very large collections.

Table 4. The rôle of the different species of parasites attacking *C. fumiferana*.

Stage of host attacked	Number of parasite species	Status as a parasite		
		Primary	Hyperparasite	Unknown
Eggs	1	1		
Overwintering larvae	3	3		
3rd stage to mature larvae	16	15	1	
Pupae	5	5		
Unknown	20	3	6	11
Totals	45	27	7	11

Of the parasites known to be primary, by far the greatest proportion (about 75 per cent) attack the larval stages of the host and to a large extent during the later stages of development. Only three species, *Glypta fumiferanae*, *Apanteles fumiferanae* and *Horogenes cacoeciae* parasitize early stage *C. fumiferana* larvae. These deposit their eggs in the host larvae soon after eclosion and remain within the host during diapause until the following spring. The adults usually emerge before completion of the host's fifth larval stadium and thus some of these species may not be reared from the collections if they are gathered late in the season. With the exception of *T. minutum*, the remainder of the more abundant primary parasites attack the late larval and pupal stages of the host. Only three (12 per cent) of the more abundant species, *Ephialtes ontario*, *Phaeogenes hariolus* and *Itoplectis obesus* parasitize the pupae. Although both *Phorocera erecta* and *Pseudosarcophaga affinis* have been observed on occasions to parasitize newly formed pupae, they appear to prefer fully mature larvae.

It is apparent from inspection of the tables that the overall controlling effect of the parasites on all stages of the host combined was relatively high. From the rearing records shown in tables 1 and 2 it may be seen that in some localities up to almost 40 per cent of the budworm collected were parasitized. In the older infestations at Mt. McLean, Mission Mountain and MacGillivray Falls the percentage parasitism was noticeably higher than at either Texas Creek or Fountain Valley where the infestations first appeared in noticeable numbers in 1946. At Mt. McLean (table 1) parasitism has remained at much the same level of 26 per cent during the past four years with the exception of 1946 when it dropped to 18

per cent. In tables 1 and 2 comparable values for total parasitism may be obtained by adding to the mass collection the percentage parasitisms of the three species not recorded in the mass collections, namely, *Glypta fumiferanae, Phytodietus fumiferanae* and *Apanteles fumiferanae*. From the special collections of the corresponding years at Fountain Valley, where mass collecting was possible for the first time in 1947, total parasitism based on the rearing of over 400,000 budworm but exclusive of *Glypta* and *Phytodietus* was just over 10 per cent. In this area *Pseudosarcophaga affinis* was by far the most abundant species present.

From the figures shown in the tables it is clear that not all the parasite species taken in the present study are of significant importance as factors of control. Of the 45 species recorded only 15 appear to be dominant in the parasite complex. These are listed in their relative order of importance as follows. In each case the species name is followed by an indication of their relative percentage parasitism (see table 1).

Glypta fumiferanae	5.18
Phytodietus fumiferanae	3.83
Omotoma fumiferanae	2.41
Ceromasia auricaudata	2.06
Lypha setifacies	1.32
Ephialtes ontario	1.95
Pseudosarcophaga affinis	1.63
Phorocera incrassata	1.10
Trichogramma minutum	0.99
Apanteles fumiferanae	0.79
Phaeogenes hariolus	0.70
Madremyia saundersii	0.65
Phorocera erecta	0.33
Itoplectis obesus	0.32
Phryxe pecosensis	0.27

Most of the others were either hyperparasitic or of infrequent or casual occurrence in the native parasite fauna of *C. fumiferana* in the Lillooet area.

SUMMARY

Extensive collections of the spruce budworm, *Choristoneura fumiferana* were made in the Lillooet area of British Columbia from 1943 to 1947 for the purpose of securing parasites for transfer to infested areas in Eastern Canada. In addition to the parasite species selected for liberation many others were reared which provided the basis for a study of the general parasite complex of *C. fumiferana* in this area.

In all, 45 species of primary and secondary parasites and one coleopteran predator were reared from the collections. Eighteen of these have not previously been reported in the literature as parasites of *C. fumiferana* and nineteen species previously recorded were not taken during the current studies. A list is given of the parasite species recorded in the literature from this host previous to the present work.

Of the 27 primary species, the majority attack the host larvae. *Trichogramma minutum* was the only egg parasite reared and it was never very abundant. Over-wintering larvae were parasitized only by *Glypta fumiferanae, Apanteles fumiferanae* and *Horogenes cacoeciae*. Fifteen species attack the larvae during their later stages of development and in most cases remain within the host until after it has pupated. Five species parasitize pupae. The stage of the host attacked by three species is unknown.

Only 15 of the total number of species taken appeared to be dominant in the parasite complex and are considered of significant importance as factors of control. Most of the others were either hyperparasitic or of infrequent or casual occurrence in the native parasite fauna of *C. fumiferana* in the Lillooet area.

The overall controlling effect of parasites in all stages of the host's development combined was high. In some years over 40 per cent of the budworm collected were parasitized. In the older infestations parasitism appeared to be definitely higher than in the more recent ones.

REFERENCES

Bedard, W. D. 1938. An annotated list of the insect fauna of Douglas Fir (*Pseudotsuga mucronata Rafinesque*) in the Northern Rocky Mountain Region. Can. Ent., 70:188-197.

Brooks, A. R. 1945. New Canadian Diptera (Tachinidae). ibid., 77:78-96.

Brown, A. W. A. 1941. Foliage Insects of Spruce in Canada. Publ. Can. Dept. Agric., No. 712 (Tech. Bull. 31): 1-29.

Brown, N. R. 1946 a. Studies on parasites of the Spruce Budworm, *Archips fumiferana* (Clem.) 1. Life History of *Apanteles fumiferanae* Viereck. Can. Ent., 78: 121-129.

Brown, N. R. 1946 b. Studies on Parasites of the Spruce Budworm, *Archips fumiferana* (Clem.) 2. Life History of *Glypta fumiferanae* (Viereck). ibid., 78:138-147.

Coppel, H. C. 1946. The collection of Spruce Budworm parasites in British Columbia with notes on their overwintering habits. 77 Ann. Rept. Ent. Soc. Ont., 38-40.

Cushman, R. A. 1920 a. The North American Ichneumon-flies of the tribe *Ephialtini*. Proc. U.S. Nat. Mus., 58:327-362.

Cushman, R. A. 1920 b. North American Ichneumon-flies of the tribes Lycorini, Polysphinctini and Theroniini. ibid., 58:7-48.

Fiske, W. F. 1903. A study of the parasites of the American tent caterpillar. Tech. Bull. N.H. Agric. Expt. Sta. 6:184-230.

Forbush, E. H. and C. H. Fernald. 1896. The Gypsey moth, *Porthetria dispar* (Linn.) Mass. Board of Agric., Wright and Potter, Boston, U.S. pp. 495.

Gibson, A. 1910. The Entomological Record for 1910. 41st Ann. Rept. Ent. Soc. Ont., 101-120.

Gibson, A. 1912. The Entomological Record for 1912. 43rd Ann. Rept. Ent. Soc. Ont., 113-140.

Girault, A. A. 1911. On the identity of the most common species of the family Trichogrammidae. Bull. Wisconsin Nat. Hist., 9:135-155.

Glendenning, R. 1921. Notes on the Fauna and Flora of Mt. McLean, B.C. Proc. Ent. Soc. B.C. 18:39-44.

Hewitt, C. G. 1911. Report of the Dominion Entomologist for the year ending March 31, 1911., Ann. Rept. Expt. Farms, 1910-1911; pp. 107-235.

Hewitt, C. G. 1912. Some of the work of the Division of Entomology in 1911., 42nd Ann. Rept. Ent. Soc. Ont., pp. 25-27.

Hewitt, C. G. 1913. Report of the Dominion Entomologist for the year ending March 31, 1912. Ann. Rept. Expt. Farms, 1911-1912., pp. 173-189.

Johnson, P. W. 1927. Biological Survey of the Mount Desert Region, Part I. The insect fauna with reference to the flora and other biological features. Wistar Inst. Anat. Biol., Philadelphia pp. 1-247.

Johannsen, O. A. 1913. Spruce budworm (*Tortrix fumiferana*, Clemens). Maine Agric. Expt. Sta. Orno, Bull. 210, pp. 12-31.

Lambert, R. 1942. Les insectes forestiers du Quebec in 1941 Nat. Canad. 69:173-250.

Mathers, W. G. 1932. The spruce budworm in British Columbia For. Chron. 8:156-160.

Mills, H. B. 1942. Montana insect pests 1941 and 1942; 29th report of the State Entomologist. Bull. Mont. Agric. Sta., No. 408:1-36.

Muesbeck, C. F. W. 1920. A revision of the North American species of the Ichneumon-flies belonging to the genus *Apanteles*. Proc. U.S. Nat. Mus. 58:483-576.

Muesbeck, C. F. W. 1923. A revision of the North American species of Ichneumon-flies belonging to the genus *Meteorus* Haliday, ibid. 63:1-44.

Rohwer, S. A. 1922. A new parasite of the spruce budworm (Hym.). Can. Ent. 54: 155-156.

Sellers, W. F. 1943. The nearctic species of parasitic flies belonging to *Zenillia* and allied genera. Proc. U.S. Nat. Mus., 93:1-108.

Swaine, J. M. and F. C. Craighead. 1924. Studies on the spruce budworm (*Cacoecia fumiferana* Clem.). Dom. Can. Dept. Agric. Bull. 37:1-91.
Tothill, J. D. 1912. Systematic notes on North American Tachinidae. Can. Ent., 44:1-5.
Tothill, J. D. 1913. Tachinidae and some Canadian hosts. ibid., 45:69-75.
Tothill, J. D. 1923. Notes on the outbreak of spruce budworm, Forest Tent caterpillar and Larch sawfly in New Brunswick. Proc. Acad. Ent. Soc., 8:172-182.
Townes, Jr., H. K. 1944. A catalogue and reclassification of the nearctic Ichnemonidae. Mem. Amer. Ent. Soc., 11:1-925.
Townsend. C. H. T. 1940. Manual of Myiology. Part 10. p. 227. Townsend and Filhos, Itaquaquecetuba, São Paulo, Brazil.
Treherne, R. C. 1915. A preliminary list of parasitic insects known to occur in Canada. 46th Ann. Rept. Ent. Soc Ont. pp 178-193.
Twinn, C. R. 1938. A summary of the insect pest situation in Canada in 1938. 69th Ann. Rept. Ent. Soc. Ont. pp. 121-134.
Viereck, H. L. 1912. Description of five new genera and 26 new species of Ichneumonflies. Proc. U.S. Nat. Mus. 42: 139-155.
Wilkes, A. 1947. The introduction of insect parasites of the spruce budworm, *Archips fumiferana* Clem. into Eastern Canada. Can. Ent. 78:82-86.
Wilkes, A. and M. Anderson. 1947. Notes on recovery of the introduced spruce budworm parasite, *Phytodietus fumiferanae* Rohwer in Eastern Canada. 77th Ann. Rept. Ent. Soc. Ont. pp. 40-44.

"The Spider Book — A Manual for the Study of Spiders and their Near Relatives, the Scorpions, Pseudo-scorpions, Whip-scorpions, Harvestmen, and other Members of the Class Arachnida, Found in America North of Mexico, with Analytical Keys for their Classification and Popular Accounts of their Habits" by John Henry Comstock. Revised and edited by J. W. Gertsch. 729 pages, 770 figures. Comstock Publishing Company, Inc., Ithaca, New York. 1948. $6.00.

The Spider Book has been out of print for a number of years. Originally published in 1912, it has served as an excellent introduction to the study of the Arachnids, the spiders in particular. Primarilyl adapted for student use, it has proven a useful reference for teachers and arrachnologists.

The author of this revision, J. W. Gertsch, Ph.D., Associate Curator, Department of Entomology, American Museum of Natural History, is a well-known arachnologist, well qualified to undertake the revision. No radical departures in form or scope from the original edition have been introduced. Controversial topics have been avoided. The sections on classification have been revised to bring the text matter into line with present knowledge of genera and species. The manual does not make reference to every species and to every genus occurring in America north of Mexico, as this would be incompatible with the purpose of the manual.

This volume should meet the present day needs of student arachnologists, as well as serving as a handy reference for teachers and entomologists in general.

THE AQUATIC COLEOPTERA OF NEWFOUNDLAND & NOVA SCOTIA
(Collection of Drs. Jaczewski & Feliksiak, 1938).

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There appear to be very few published records of the species of the Aquatic Coleoptera found in Newfoundland and Nova Scotia. According to Hatch (1928, J. New York Ent. Soc., 36:335-354) only two papers deal with the Coleoptera of Nova Scotia and in each of these papers only a single species of the families of the aquatic beetles is named. Hatch also gives four references to the water beetles of the Labrador Province of Newfoundland; from these I have been able to extract a total of five species listed from Newfoundland proper and a further two species from Nova Scotia. An exhaustive search of literature, including the Leng Catalogue and Supplements, has produced a total of 31 species as previously known from Newfoundland proper, of which two species (*Hydroporus obscurus* Sturm & *Oreodytes alpinus* Payk.) must be deleted as erroneous; also 6 species as previously known from Nova Scotia, of which one species (*Dytiscus marginalis* L.) must be deleted as recorded in error.

In 1939 I received the aquatic Coleoptera collected in 1938 in Newfoundland, Nova Scotia and the Islands of St. Pierre and Miquelon by Drs. Jaczewski & Feliksiak of the Polish National Museum, Warsaw, for identification. It is felt that the lists of species present in these collections is of sufficient interest to justify the publication of complete lists of all the species now known to occur in each province. There is no doubt that these lists are by no means exhaustive; on a comparison with the lists for neighouring provinces it is evident that about one-third greater numbers are to be expected, but it is felt that the subjoined lists will serve as a preliminary basis for further studies in distribution.

Of the 29 species already recorded from Newfoundland 10 are not present in the collection of Jaczewski and Feliksiak, which amount to 45 species. This total of 55 species is poor when compared with the total of 80 species from the neighbouring areas of Quebec (Brown 1930, Can. Ent. 62: 233-237, 239; 64: 198-209). Analysis of the total of 55 species from Newfoundland shews that 14 species have so far been found in Newfoundland which are not recorded from eastern Quebec and that of these 14 species 8 are common to Newfoundland and Nova Scotia; further that 20 species have so far been found in Newfoundland which are not known from Nova Scotia.

There are not, to my knowledge, any existing published records for the aquatic Coleoptera of St. Pierre & Miquelon. The 11 species taken are all common to Newfoundland and, with one exception, to Nova Scotia.

Of the five existing records for Nova Scotia two species are not present in the collections of Jaczewski and Feliksiak, which amount to 52 species. The total of 54 species recorded here compares well with the Newfoundland figure. Analysis shews that no fewer than 27 species have, so far, been found in Nova Scotia but not in Newfoundland; further, that of this 27 only three are common to Nova Scotia and eastern Quebec and may, therefore, be expected to occur in Newfoundland.

A further analysis of the Nova Scotian figures shews that 29 species occur in the mainland which are apparently not present in Cape Breton Island; of this number 14 are common to the mainland and Newfoundland and 1 is common to mainland and eastern Quebec but has not yet been taken in Newfoundland; it appears, therefore, that some 14 species only are at, or near, their north-eastern limit of distribution in the mainland.

I am unable to find any published records for the provinces of Prince Edward Island and New Brunswick. It is therefore not possible to make any

direct link between the Nova Scotian fauna and Quebec, in particular for the portion of the province south of the St. Lawrence.

For convenience it has been thought better to keep the lists for each of the three divisions separate as forming more easily consulted Check Lists.

LIST OF COLLECTING STATIONS

1.	Beechville, near Halifax.	2. viii. 1938.	Nova Scotia.
2.	Beechville, near Halifax.	7. viii. 1938.	do.
3.	Lovett's Lake, near Halifax.	7. viii. 1938.	do.
5.	Chainy Lake, near Halifax.	7. viii. 1938.	do.
6.	Cole Harbour, near Halifax.	9. viii. 1938.	do.
7.	Cole Harbour, near Halifax.	9. viii. 1938.	do.
8.	Cole Harbour, near Halifax.	9. viii. 1938.	do.
9.	Between Dartmouth and Upper Lawrence Town, Halifax.	9. viii. 1938.	do.
10.	Salmon River, near Truro.	11. viii. 1938.	do.
12.	Truro.	13. viii. 1938.	do.
13.	Onslow, near Truro.	13. viii. 1938.	do.
14.	Onslow, near Truro.	13. viii. 1938.	do.
15.	Salmon River, near Truro.	14. viii. 1938.	do.
17.	Merigonish.	15. viii. 1938.	do.
18.	Merigonish.	16. viii. 1938.	do.
19.	Merigonish.	16. viii. 1938.	do.
21.	North Sydney, Pottle Lake.	18. viii. 1938.	do.
22.	North Sydney, Pottle Lake.	18. viii. 1938.	do.
23.	North Sydney, Pottle Lake.	18. viii. 1938.	do
24.	North Sydney.	19. viii. 1938.	do.
25.	Pottle Lake, North Sydney.	19. viii. 1938.	do.
26.	Pottle Lake, North Sydney.	19. viii. 1938.	do.
27.	North Sydney.	19. viii. 1938.	do.
28.	Johnson Lake, near North Sydney.	19. viii. 1938.	do.
30.	Between Johnson Lake and West Arm, Sydney Harbour.	19. viii. 1938.	do.
31.	Port aux Basques.	21. viii. 1938.	Newfld.
31a.	Port aux Basques.	21. viii. 1938.	do.
32.	Port aux Basques.	21. viii. 1938.	do.
33.	Port aux Basques.	23. viii. 1938.	do.
34.	Port aux Basques.	23. viii. 1938.	do.
37.	Port aux Basques.	22. viii. 1938.	do.
38.	St. Georges.	24. viii. 1938.	do.
39.	St. Georges.	24. viii. 1938.	do.
40.	St. Georges.	24. viii. 1938.	do.
41.	St. Georges.	24. viii. 1938.	do.
43.	St. Georges.	25. viii. 1938.	do.
45.	Corner Brook.	27. viii. 1938.	do.
47.	Corner Brook.	27. viii. 1938.	do.
48.	Corner Brook.	27. viii. 1938.	do.
49.	Corner Brook.	28. viii. 1938.	do.
52.	Deer Lake.	30. viii. 1938.	do.
53.	Deer Lake.	30. viii. 1938.	do.
55.	Deer Lake.	1. ix. 1938.	do.
56.	Deer Lake.	1. ix. 1938.	do.
57.	Humber River, Deer Lake.	1. ix. 1938.	do.
58.	Grand Falls.	3. ix. 1938.	do.
59.	Grand Falls.	4. ix. 1938.	do.
60.	Terra Nova.	5. ix. 1938.	do.

61.	Pitts-Brook River, Terra Nova.	5. ix. 1938.	do.
62.	Terra Nova.	5. ix. 1938.	do.
63.	Terra Nova.	6. ix. 1938.	do.
64.	Terra Nova.	6. ix. 1938.	do.
65.	Terra Nova.	6. ix. 1938.	do.
67.	Ferryland.	10. ix. 1938.	do.
68.	Ferryland.	10. ix. 1938.	do.
69.	Ferryland.	10. ix. 1938.	do.
70.	Signal Hill, near St. Johns.	11. ix. 1938.	do.
71.	Signal Hill, near St. Johns.	11. ix. 1938.	do.
74.	Signal Hill, St. Johns.	11. ix. 1938.	do.
75.	Lamaline.	14. ix. 1938.	do.
76.	St. Pierre.	16. ix. 1938.	St. Pierre.
78.	St. Pierre.	15. ix. 1938.	do.
79.	St. Pierre.	15. ix. 1938.	do.
80.	St. Pierre.	15. ix. 1938.	do.
81.	Grande Miquelon.	16. ix. 1938.	Miquelon.
83.	Grande Miquelon.	16. ix. 1938.	do.
84.	Grande Miquelon.	16. ix. 1938.	do.
85.	St. Pierre.	17. ix. 1938.	St. Pierre.
87.	North Sydney.	18. ix. 1938.	Nova Scotia.
88.	North Sydney.	18. ix. 1938.	do.
90.	North Sydney.	18. ix. 1938.	do.
91.	North Sydney.	18. ix. 1938.	do.
92.	Halifax, Point Pleasant Park.	22. ix. 1938.	do.
93.	Halifax, Point Pleasant Park.	21. ix. 1938.	do.
94.	Halifax, Point Pleasant Park.	21. ix. 1938.	do.
96.	Windsor.	23. ix. 1938.	do.
97.	Pembertons, near Windsor.	23. ix. 1938.	do.
98.	Three Mile, near Windsor.	23. ix. 1938.	do.
101.	Lequille, near Annapolis Royal.	24. ix. 1938.	do.
102.	Lequille, near Annapolis Royal.	24. ix. 1938.	do.
104.	Annapolis Royal.	25. ix. 1938.	do.
105.	Moschelle, near Annapolis Royal.	25. ix. 1938.	do.
106.	Yarmouth.	27. ix. 1938.	do.
107.	Yarmouth, Arcadia Indian Reservation.	27. ix. 1938.	do.
108.	Yarmouth, Arcadia Indian Reservation.	27. ix. 1938.	do.
109.	Yarmouth.	27. ix. 1938.	do.
110.	Yarmouth.	27. ix. 1938.	do.
111.	Halifax, Public Garden.	23. ix. 1938.	do.
192.	Halifax, Point Pleasant Park.	21. ix. 1938.	do.
A.	St. Georges.	24. viii. 1938.	Newfld.
B.	Corner Brook.	27. viii. 1938.	do.
C.	Corner Brook.	28. viii. 1938.	do.

NEWFOUNDLAND

Haliplidae.

Haliplus immaculicollis Harris. Stations; 39, one specimen; 45, one specimen; 47, one specimen; 48, two specimens; 56, one specimen; 58, two specimens; 59, one specimen; 62, one specimen; 75, 5 ♂, 7 ♀.

Haliplus cribrarius LeConte. Stations: 53, 1 ♂, 1 ♀; 56, 1 ♀; 58, 1 ♀.

Haliplus sp. near *subguttatus* Robts. A single female from station 48 which I am unable to determine with certainty. It is undoubtedly close to *subguttatus* and runs to that species in Wallis key (1933, Wallis, J. B., Trans. Canad. Inst., 19: pp. 1-76) but it does not entirely agree with other material from Nova Scotia and from other parts of the continent.

Dytiscidae

Hygrotus sayi J.B-B. (*punctatus* Say *nec* Marsh.) Stations: 53, one specimen; 55, five specimens; 56, 58 specimens; 58, four specimens; 59, two specimens; 61, one specimen; 62, five specimens; 63, one specimen; 70, one specimen.

Hygrotus (*Coelambus*) *impressopunctatus* (Schall.) Station 61, one specimen.

Hygrotus (*Coelambus*) *suturalis* (LeConte). Station 48, two females. This is an interesting occurrence since the known records for the species are mostly in Manitoba and Ontario Provinces and I have seen no records for Quebec Province. The two specimens before me agree closely with specimens in the British Museum from "Lake Superior" and Mile 214, H.B.Ry, (Wallis Coll.).

Hygrotus (*Coelambus*) *quebecensis* Brown. Stations: 31a, 3 ♂, 2 ♀; 33, 1 ♂, 1 ♀; 34, 3 ♀. Described from material taken on the Quebec shore of the Belle Isle Straits separating Newfoundland from the mainland.

Bidessus affinis (Say). Stations: 56, 1 ♀; 75, 1 ♂.

Hydroporus signatus Mann. Stations: 31a, 1 ♂; 34, 1 ♂; 37, 1 ♂; 39, 3 ♂, 2 ♀; 68, 2 ♂.

Hydroporus niger Say. Station 48, 1 ♀.

Hydroporus notabilis LeConte. Station 67, 1 ♀; 70, 1 ♂, 1 ♀; 74, 1 ♀. I am by no means certain that the identification of the two females from stations 67 and 74 is correct. They appear to agree with authentic females of this species but the size is rather on the small side and they suggest to me more the preceding species from which I find it difficult to make a decisive determination in the absence of the male. Either of these species is likely to be met with.

Hydroporus undulatus Say. An examination of almost three thousand specimens from the north eastern States of the United States and from eastern Canada belonging to the *undulatus-consimilis-lynceus* complex has left me convinced that there is no taxonomic 'specific' distinction between these forms as suggested by Sharp and Fall. Various minor distinctions which follow to some extent along geographical separation trends can be discerned in an examination of long series but I am unable to accept the contentions of Fall that these distinctions are of a degree distinct enough to merit a specific category. The form usually considered to occur in Newfoundland is that known as *consimilis*, in which the prothoracic margin is said to be narrower than in *undulatus* and in which the punctation of the dorsum is said to be denser. Somewhat wide variations of the width of the marginal beading of the pronotum have been found but random sampling of a considerable number of specimens has not shewn that the mean width is significantly different between specimens from a '*consimilis* district' and from an '*undulatus* district'; punctation has been found to shew considerable variation amongst local populations and therefore to be an unreliable basis for deducing specific distinctions; colour variation is extreme but local in character and a completely inacceptable basis for specific status.

It is hoped, at a later date, to prepare a full statistical analysis of this material to ascertain and illustrate the trends towards subspeciation.

Stations: 33, 40 ♂, 23 ♀; 47, 1 ♂, 1 ♀; 48, 11 ♂, 7 ♀; 58, 2 ♂, 2 ♀; 61, 2 ♂; 62, 4 ♀; 63, 1 ♂, 1 ♀; 68, 4 ♂, 8 ♀; 75, 7 ♂, 17 ♀.

Hydroporus carolinus Fall. Stations: 41, 1 ♂; 43, 1 ♀; 71, 1 ♀.

Hydroporus solitarius Sharp. Station 57, 1 ♂.

Hydroporus clypealis Sharp. Station 41, 1 ♂.

Hydroporus brevicornis Fall. Stations: 32, 2 ♀; 34, 1 ♂, 2 ♀; 39, 1 ♀.

(*Hydroporus badiellus* Fall. Previously recorded, not in Jaczewski collection.)

(*Hydroporus striola* (Gyll.). Previously recorded, not in Jaczewski collection).

Potamonectes griseostriatus (Deg.). Station 48, 1 ♀; also seen from Harbour Buffet, (ex coll. E. J. Pearce).

Potamonectes depressus elegans (Panz.). This species is usually recorded from North America as "*Deronectes depressus* Fab." but all the specimens I have seen from any locality in Canada or the United States have the acutely pointed median lobe of the aedeagus characteristic of the form known in Europe as *elegans* (Panz.), where there is every degree of gradation from one form to the other. It appears that in Europe the complex is best regarded as a 'cline' and it is interesting that there the progression appears to be from south-east (*elegans*) to north-west (*depressus*), but that *depressus* stretches out in a long, narrow finger, across the boreal palaearctic into Siberia. The two areas in which *elegans* is present are therefore very widely separated.

Stations: 48, 6 ♂, 3 ♀; 57, 1 ♂; 61, 7 specimens; 62, 4 ♂, 2 ♀.

(*Oreodytes rivalis* (Gyll.). (*obesus* LeC.). Previously recorded as *Hydroporus septentrionalis* (Gyll.). The true *septentrionalis* is not known from the nearctic region and undoubtedly the species intended is that named above.).

Agabus phaeopterus (Kby.). Stations: 39, 1 ♂; 71, 1 ♀; B, 1 ♂.

Agabus seriatus seriatus (Say) Leech. Station 71, 1 ♂.

(*Agabus punctulatus* Aubé. Previously recorded, not present in Jaczewski collection).

(*Agabus semipunctatus* (Kby.). Previously recorded, not present in Jaczewski collection).

Agabus ambiguus (Say). Stations: 39, 1 ♂; 71, 1 ♂, 2 ♀.

Agabus anthracinus (Mann.). Stations: 33, 1 ♂; 49, 1 ♀; 70, 3 ♀; 71, 1 ♀.

Agabus erichsoni Gemm & Har. Station B, 1 ♀.

Ilybius pleuriticus (LeConte). Stations: 31, 1 ♂; 32, 1 ♀; 34, 1 ♂, 1 ♀; 37, 1 ♀; 48, 1 ♂.

Ilybius biguttulus (Germ.). Station 58, 1 ♂.

Ilyius discedens Sharp. Station 39, 1 ♀.

Ilybius angustior (Gyll.). Station 70, 2 ♂.

(*Ilybius subaeneus* Er. Previously recorded, not present in Jaczewski Collection).

Rhantus binotatus (Harr.). Stations 38, 1 ♂, 3 ♀.

Rhantus zimmermanni Wallis. Stations: 32, 1 ♂; 34, 4 ♀; 39, 4 ♂, 1 ♀; 53, 1 ♀; 60, 1 ♀; 63, 1 ♂; 64, 1 ♂; 71, 1 ♂; 74, 1 ♂.

Rhantus suturellus (Harr.). Stations: 56, 1 ♂; 65, 1 ♂; 70, 3 ♀.

Colymbetes paykulli Er. (*longulus* LeConte). Station 64, 1 ♀.

Graphoderus liberus (Say). Stations: 60, 2 ♂; 63, 6 ♂, 3 ♀; 64, 1 ♂; 65, 3 ♂, 2 ♀.

(*Acilius fraternus* (Harr.). Previously recorded. I do not think this species is present in Jaczewski collection; all examples appear to belong to the following species).

Acilius semisulcatus Aubé. Stations: 45, 1 ♀; 58, 1 ♂, 1 ♀; 59, 1 ♂; 62, 1 ♀; 63, 1 ♂, 2 ♀; 65, 2 ♀; 70, 1 ♂.

Dytiscus ooligbuckii Kirby (nec. auctt.). (*parvulus* Mann., *alaskanus* J.B-B.). As I have recently discovered (Ann. Mag. Nat. Hist. in Press) *ooligbuckii* has been misinterpreted by all recent authors. It is not, as supposed, a synonym of *dauricus* Gebl. but is that species which I recently re-named *alaskanus* (1944, Ann. Mag. Nat. Hist. (XI) 11:356), *parvulus* Mann. being a homonym. Station 45, 1 ♂.

Gyrinidae

Gyrinus latilimbus Fall. Station 63, 1 ♀.

Gyrinus lugens LeConte. Stations: 31, three specimens; 33, 18 specimens; 47, one specimen; 58, one specimen; 68, eight specimens; 75, one specimen.

Gyrinus bifarius Fall. Stations: 40, 1 ♂, 3 ♀; 48, 1 ♂, 1 ♀; 62, 1 ♀.

Gyrinus dubius Wallis. Station 63, 1 ♂.

Gyrinus minutus Fab. Stations: 31, 8 ♂, 5 ♀; 33, 1 ♂, 1 ♀; 52, 3 ♂; 63, 2 ♂, 2 ♀; 65, 1 ♀; 70, 1 ♀.

Hydrophilidae

Anacaena limbata Fab. Stations: 38, two specimens; 49, one specimen; 61, one specimen; 68, one specimen; 69, two specimens; 70, one specimen; A, one specimen; C, one specimen.

Laccobius agilis (Rand.). Station 40, 1 ♀.

Enochrus sp. (*hamiltoni* auctt. Horn partim). According to my friend, Hugh B. Leech of Vernon, B. C., this form has been confused with the true *hamiltoni* Horn. At the time of writing I do not think that the present species has been defined, nor, I believe has it yet received a name. Certainly all the material before me agrees with specimens sent me by Leech and are distinct from specimens labelled by him as authentically Horn's species. Stations: 58, 1 ♀; 69, 1 ♂; 70, 4 ♂, 4 ♀.

Enochrus ochraceus (Melsh.): Station 60, 2 ♂, 1 ♀.

(*Cymbiodyta fimbriata* (Melsh.). Previously recorded. I am, however, satisfied that all the material before me belongs not to the present but to the following species.).

Cymbiodyta vindicata Fall. Stations: 34, 1 ♀; 63, 1 ♀; 71, 1 ♂, 1 ♀.

Hydrobius fuscipes (Linn.). Stations: 38, 2 ♀; 70, 12 ♂, 6 ♀.

(*Helophorus lineatus* (Say). Previously recorded. No specimens of this genus are included among the material collected by Dr. Jaczewski.).

ST. PIERRE & MIQUELON

Haliplidae

Haliplus immaculicollis Harr. Stations: 76, four specimens; 80, three specimens; 84, one specimen; 85, one specimen.

Dytiscidae.

Hygrotus (*Coelambus*) *quebecensis* Brown. Station: 84, 8 ♂, 10 ♀.

Hydroporus signatus Mann. Stations: 76, 1 ♀; 78, 1 ♂, 80, 1 ♂.

Hydroporus niger Say. Station 84, 1 ♀.

Hydroporus undulatus Say. Stations: 76, 4 ♂, 10 ♀; 79, 1 ♀; 81, 2 ♂, 3 ♀; 85, 1 ♀.

Ilybius pleuriticus LeConte. Station 76, 1 ♀.

Ilybius angustior (Gyll.). Station 84, 1 ♀.

Gyrinidae

Gyrinus lugens LeConte. Stations: 76, 5 ♂; 80, 1 ♂; 81, 13 ♂, 9 ♀; 83, 2 ♂; 85, 3 ♂.

Gyrinus minutus Fab. Station 81, 1 ♂, 2 ♀.

Hydrophilidae

Anacaena limbata (Fab.). Station 78, 1 ♀.

NOVA SCOTIA

Haliplidae

Haliplus immaculicollis Harr. Stations: 1, one specimen; 6, three specimens; 9, three specimens; 10, six specimens; 12, two specimens; 13, one specimen; 15, three specimens; 18, one specimen; 21, two specimens; 25, two specimens; 30, one specimen; 87, four specimens; 88, two specimens; 91, ten specimens; 92, one specimen; 96, two specimens; 98, 13 specimens; 101, one specimen; 104, ten specimens; 105, five specimens; 109, one specimen; 110, 17 specimens; 111, 19 specimens.

Haliplus longulus LeConte. Stations: 7, 3 ♂, 1 ♀; 18, 2 ♂, 1 ♀; 24, 3 ♂, 1 ♀; 91, 1 ♂, 3 ♀; 110, 1 ♂.

Haliplus cribrarius LeConte. Stations: 6, 1 ♂; 25, 1 ♂, 3 ♀; 30, 2 ♂, 1 ♀; 104, 1 ♀; 110, 1 ♂.

Haliplus canadensis Wallis. Station 10, 1 ♂.

Haliplus connexus Math. Stations: 10, 5 ♂, 8 ♀; 104, 1 ♂, 1 ♀; 109, 1, ♂; 110, 2 ♂, 7 ♀.

Haliplus subguttatus Robts. Stations: 91, 1 ♂, 1 ♀; 104, 1 ♀.

Peltodytes edentulus LeConte. Stations: 10, 4 ♂, 6 ♀; 12, 1 ♂, 3 ♀.

Peltodytes tortulosus Robts. Stations: 10, 1 ♂; 12, 3 ♀.

Dytiscidae

Hygrotus sayi B-B. Stations: 1, three specimens; 5, one specimen; 6, two specimens; 12, one specimen; 21, one specimen; 23, one specimen; 91, five specimens; 92, six specimens; 98, 15 specimens; 107, five specimens; 108, two specimens; 192, four specimens.

Hygrotus (*Coelamus*) *impressopunctatus* (Schall.). Stations: 6, 1 ♂; 14, 1 ♂; 87, 1 ♂, 2 ♀.

Hygrotus (*Coelambus*) *turbidus* Fall. Stations: 87, one specimen; 91, three specimens; 98, one ♂.

Hydroporus signatus Mann. Stations: 6, 2 ♀; 8, 1 ♀; 93, 2 ♀.

Hydroporus niger Say. Stations: 6, 1 ♂; 26, 1 ♂, 6 ♀; 27, 1 ♂, 1 ♀; 87, 1 ♂; 91, 3 ♂; 96, 1 ♂, 1 ♀; 105, 1 ♂.

Hydroporus notabilis LeConte. Station 87, 1 ♂, 1 ♀.

Hydroporus dentellus Fall. Stations: 6, 4 ♂; 105, 3 ♂.

Hydroporus undulatus Say. Stations: 3, 2 ♂, 1 ♀; 5, 2 ♂, 1 ♀; 6, 42 ♂, 27 ♀; 8, 2 ♂, 1 ♀; 10, 3 ♂, 4 ♀; 12, 2 ♂, 3 ♀; 13, 1 ♂; 91, 1 ♂, 1 ♀; 105, 12 ♂, 11 ♀; 107, 2 ♂, 1 ♀; 108, 1 ♂; 111, 1 ♂.

Hydroporus carolinus Fall. Station 27, 20 specimens.

Hydroporus solitarius Sharp. Stations: 10, 21 specimens; 96, 1 ♂, 2 ♀.

Hydroporus clypealis Sharp. Stations: 6, 2 ♀; 104, 1 ♂, 2 ♀; 105, 3 ♂, 3 ♀; 106, 1 ♂, 1 ♀; 109, 1 ♀; 110, 1 ♂, 1 ♀.

Hydroporus pulcher LeConte. Station 90, 1 ♂, 1 ♀.

Hydroporus brevicornis Fall. Station 6, 1 ♀.

Hydroporus striola (Gyll.). Station 24, 1 ♂, 1 ♀.

Hydroporus acadianus sp. n

Ovalis, depressiusculus, glabriusculus, castaneus; capito tenuiter sat crebre irregulariter, inaequaliter punctulato; pronoto lato, transverso, ab basin distincte, in disco pertenuissime sparsim punctulato, lateraliter fortiter marginato; elytris sat fortiter copioso sed non confertim irregulariter punctulatis, seriebus systematicis indistinctis; omnino pertenuissime vix visibiliter microreticulato, areolis rotundatis perminutis; subtus nigricans, segmentis abdominis lateraliter rufescentibus; processu prosternali elongato-lanceolato, apice rotundato, transversim levissime convexo; metasterno in medio tenuissime sparsim, ad lateres fortiore et crebriore, metacoxis fortiter minus crebre punctatis; tibiis anticis maris subtus prope basin emarginatis, feminae simplicis.

Head castaneous, with the transverse width between the eyes five times the width of an eye, the eyes small, one-seventh the width of the head; finely, quite closely but irregularly and unequally punctulate; very finely microreticulate, the areolae rounded. *Antennae* not very long, clear castaneous. *Pronotum* wide, transverse, the sides weakly rounded-convergent anteriorly, strongly margined; at the base quite strongly distinctly but shallowly punctate, on the disc the posterior angles rectangular, the base exactly as wide as the base of the elytra. *Elytra* castaneous, in the basal half the sides subparallel, the apex attenuate; extremely finely and sparingly punctulate; extremely finely microreticulate; quite strongly and copiously but not closely, irregularly punctate, the 'systematic series' indistinct, defined more by a very shallow longitudinal impression visible only in an oblique aspect than by a distinct series of punctures; extremely finely, scarcely visibly microreticulate, the areolae rounded, extremely small. *Venter* blackish, the sides of the ventrites reddish; prosternum between the procoxae with a distinct transverse 'step' at the base of the prosternal process; prosternal process elongate-lanceolate, the apex rounded, transversely weakly convex; metasternum in the middle finely, towards the sides rather strongly and fairly copiously punctate; metacoxae less strongly more sparingly and shallowly punctate, the interstices about three times the diameter of the punctures. *Legs* reddish-testaceous, the protibae of the male distinctly emarginate near the base beneath, protibae of the female simple; three basal segments of the anterior tibiae in the male slightly wider than in the female. *Aedeagus* simple, the median lobe

parallel-sided to three-fifths of the length from the base, then quite abruptly and strongly narrowed, the apical fifth very narrow, needle-like; lateral lobes alike.

Holotype ♂, *Nova Scotia*: Cape Breton Island; Johnson Lake, near North Sydney, 19.viii.1938. 4.095 mm. long., 1.995 mm. lat.

Allotype ♀, *Nova Scotia*: Cole Harbour, near Halifax, 9.viii.1938. 3,920 mm. long., 1.820 mm. lat.

This new species of the *oblitus*-group comes extremely close to *paugus* Fall which it resembles in size and in the form of the aedeagus. It nevertheless seems to me to be distinct owing to the smaller eyes, the broader, flattened marginal pronotal beading, the evidently sparser punctation at the base of the pronotum and on the elytra and the absence of disinct larger punctures, at least in the basal half, in the course of the 'systematic series'; the needle-like distal fifth of the median aedeagal lobe is rather longer than in *paugus* though the aedeagus is of the same character as in that species. In such specimens of *paugus* as I have seen the vertex of the head and the disc of the pronotum are widely suffused with black or blackish whereas in *acadianus* the whole insect is clear castaneous.

The type of this new species is at present in my care but it will ultimately be returned to the Polish National Museum along with most of the material of the collection.

Potamonectes depressus elegans (Panz.). Stations: 10, 1 ♂; 25, 5 ♂, 2 ♀; 96, 1 ♀.

Copelatus glyphicus (Say). Station 7, 1 ♀.

Agabus phaeopterus (Kby.). Stations: 24, 2 ♂, 1 ♀; 27, 3 ♂, 9 ♀.

Agabus seriatus seriatus (Say) Leech. Stations: 27, 1 ♂; 101, 1 ♂.

(*Agabus semipunctatus* (Kby.). Previouslly recorded, not present in Jaczewski collection).

Agabus erythropterus (Say). Stations: 27, 1 ♂, 1 ♀; 107, 1 ♂.

Agabus ambiguus (Say). Station 27, 4 ♂.

Ilybius pleuriticus (LeConte). Stations: 1, 1 ♀; 3, 1 ♂; 14, 1 ♀.

Ilybius biguttulus (Germ.). Stations: 1, 1 ♂, 1 ♀; 6, 1 ♂, 1 ♀; 7, 4 ♂; 8, 1 ♂, 4 ♀; 12, 1 ♂; 27, 3 ♀; 28, 1 ♀; 87, 1 ♂, 1 ♀; 94 1 ♀; 98, 1 ♂; 105, 3 ♀; 108, 1 ♀; 192, 2 ♂, 1 ♀.

Ilybius angustior (Gyll.). Station 7, 1 ♂.

Coptotomus interrogatus (Fab.). Stations: 1, 1 ♂; 2, 1 ♀; 8, 1 ♀; 13, 1 ♂; 92, 1 ♂; 98, 1 ♂; 107, 4 ♂, 5 ♀; 108, 1 ♂; 192, 1 ♂, 1 ♀.

Rhantus binotatus (Harr.). Stations: 7, 1 ♂; 92, 1 ♂; 107, 1 ♀; 108, 1 ♀; 192, 1 ♂, 1 ♀.

Rhantus zimmermanni Wallis. Station 7, 1 ♂.

Rhantus suturellus (Harr.). Stations: 7, 1 ♂; 92, 1 ♂; 107, 1 ♀; 108,

Colymetes paykulli Er. (*longulus* LeC.). Station 26, 1 ♀.

Colymbetes sculptilis Harr. Stations: 87, 1 ♂; 91, 1 ♂.

Graphoderus liberus (Say). Station 192, 2 ♂.

Acilius semisulcatus Aubé. Stations: 19, 1 ♂, 1 ♀; 91, 1 ♂, 3 ♀; 107, 1 ♂; 108, 1 ♀; 111, 1 ♀; 192, 4 ♀.

Acilius mediatus (Say). Station 93, 1 ♂.

Laccophilus maculosus (Germ.). Stations: 1, one specimen; 5, one spe-

cimen; 6, one specimen; 10, one specimen; 12, 3 ♂, 5 ♀; 21, 1 ♀; 91, 15 ♂, 12 ♀; 92, 6 ♂, 3 ♀; 96, 1 ♀; 98, 10 ♂, 11 ♀; 101, 1 ♂; 102, 11 specimens; 104, 1 ♀; 105, 2 ♀; 107, 22 specimens; 108, 1 ♂, 1♀; 110, 1 ♀; 111, 1 ♀; 192, 2 ♂, 6 ♀.

Dytiscus verticalis Say. Station 91, 1 ♂.

Gyrinidae.

Gyrinus latilimbus Fall. Stations: 12, 1 ♂; 94, 1 ♀.

Gyrinus lugens LeConte. Stations: 1, ♂, 3 ♀; 8, 1 ♀; 12, 1 ♂, 1 ♀; 21, 1 ♂, 1 ♀; 25, 1 ♂; 27, 1 ♀; 93, 2 ♀; 94, 2 ♀; 96, 1 ♀; 101, 1 ♀; 104, 13 ♂, 26 ♀; 107, 3 ♂, 3 ♀; 108, 1 ♀; 109, 1 ♂, 1 ♀; 110, 63 specimens.

Gyrinus affinis Aubé. Stations: 93, 1 ♂; 96, 1 ♂; 104, 3 ♂, 3 ♀.

Gyrinus ventralis Kby. Stations: 101, 1 ♀; 104, 5 ♀.

Gyrinus acquiris LeConte. Stations: 21, 1 ♀; 22, 1 ♂, 1 ♀.

(*Gyrinus analis* Say. Previously recorded, not in Jaczewski collection.)

Gyrinus minutus Fab. Station 107, 1 ♂.

Dineutus horni Robts. Station 3, 1 ♂, 3 ♀.

Dineutus nigrior Robts. Stations: 21, 1 ♀; 107, 18 ♂, 28 ♀; 192, 5 ♂, 2 ♀.

Hydrophilidae

Anacaena limbata (Fab.). Stations: 18, two specimens; 21, one specimen; 105, 1 ♀.

Laccobius agilis (Rand.). Stations: 15, 1 ♂; 87, 1 ♂; 106, 1 ♀.

Enochrus sp. (*hamiltoni* auctt. Horn partim). Stations 6, 1 ♂; 7, 4 ♀; 17, 6 ♂, 3 ♀; 27, 1 ♀.

Enochrus ochraceus Melsh. Stations: 21, 1 ♂; 105, 1 ♂, 2 ♀.

Cymbiodyta vindicata Fall. Stations: 26, 2 ♀; 27, 2 ♀; 105, 1 ♀.

Hydrobius fuscipes (Linn.). Stations: 24, 1 ♀; 27, 1 ♀; 87, 1 ♂; 106, 4 ♂, 1 ♀.

Berosus striatus (Say). Stations: 12, 1 ♀; 97, 1 ♂; 98, 4 ♂, 3 ♀; 102, 1 ♀; 104, 1 ♂; 108, 2 ♂; 110, 1 ♂, 5 ♀.

Tropisternus lateralis (Fab.). Stations: 108, 1 ♂.

Tropisternus natator d'Orch. Stations: 14, 1 ♀; 91, 1 ♂, 2 ♀; 97, 1 ♀; 98, 2 ♂, 2 ♀; 102, 1 ♂.

Topisternus modestus d'Orch. Stations: 12, 1 ♀; 91, 15 ♂, 11 ♀; 98, 4 ♂, 3 ♀; 101, 1 ♀; 102, 2 ♂, 2 ♀; 108, 1 ♂, 1 ♀.

NEW NEARCTIC CRANE-FLIES (TIPULIDAE, DIPTERA): PART XXIX

BY CHARLES P. ALEXANDER,
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The preceding part under this general title was published in 1947 (Can Ent., 79: 68-73). At this time I am describing a small series of Eriopterine crane-flies from California, taken chiefly by myself in 1946, with one further species secured by Mr. John L. Sperry. The types of the novelties are preserved in my collection of Tipulidae.

Erioptera (Psiloconopa) bisulca n. sp.

Thoracic dorsum pale brownish yellow, the pleura somewhat clearer yellow; antennae with scape and pedicel brownish black, the flagellum paler brown; wings pale grayish yellow; cell M_2 open by the atrophy of *m*; vein *2nd A* short and straight; male hypopygium having the outer dististyle with its outer two-thirds expanded into an elongate head; inner dististyle shorter, the apical third narrowed into a long recurved spine, the outer margin of the basal portion produced into a triangular point; gonapophyses profoundly bifid, heavily blackened, the two slender arms spinelike, the inner one with its inner margin provided with microscopic teeth.

Male. Length about 4.5-5 mm.; wing 5-5.8 mm.

Female. Length about 5-5.5 mm.; wing 5-5.5 mm.

Rostrum and palpi brownish black. Antennae with scape and pedicel brownish black, flagellar segments paler brown; verticils long and conspicuous. Head light gray.

Pronotum and mesonotum almost uniformly pale brownish yellow, not or scarcely patterned; pseudosutural foveae pale and inconspicuous, the tuberculate pits a trifle darker in color. Pleura and pleurotergite somewhat clearer yellow. Halteres yellow. Legs with the coxae and trochanters yellow; remainder of legs testaceous brown to pale brown, the outer tarsal segments darker. Wings pale grayish yellow, the prearcular and costal fields somewhat clearer yellow; veins pale brownish yellow, the macrotrichia darker. Venation: cell M_2 open by the atrophy of *m*; *m-cu* a short distance before the fork of *M*; vein *2nd A* straight, the Anal veins thus strongly divergent.

Abdomen reddish brown, the hypopygium somewhat darker, the styli blackened. Male hypopygium with the outer dististyle expanded at near one-third the length into a long narrow head, the outer surface with rows of abundant appressed spines. Inner dististyle shorter, the apical third narrowed into a long slender recurved spine, near its base with one or two setae; outer margin of the basal part produced into a conspicuous triangular point. Gonapophysis profoundly bifid, heavily blackened, the outer arm a longer and more slender spine, its outer surface, especially near the tip, microscopically spinulose or roughened; inner arm a stouter and slightly shorter curved spine, its inner margin with microscopic appressed teeth.

Habitat. California (Yosemite National Park).

Holotype. ♂, Bridalveil Creek, altitude 7075 feet, July 22, 1946 (C. P. Alexander). *Allotopotype.* ♀, pinned with type. *Paratopotypes.* ♂ ♀, July 22-24, 1946.

The most similar regional species is *Erioptera* (*Psiloconopa*) *recurva* Alexander, of the Cascade mountains in Washington. The two flies are separated by conspicuous differences in the male hypopygium, including both dististyles and the gonapophyses.

Erioptera (Gonomyodes) crickmeri n. sp.

General coloration of thorax almost uniformly dark gray; palpi and antennae uniformly black; wings with a very faint grayish tinge, the veins brown, darker than in *knowltonia; Rs* relatively short; cell 1*st* M_2 small, *m-cu* at near midlength; male hypopygium of the characteristic structure of the subgenus, differing from *knowltonia* in all details.

Male. Length about 3.5 mm.; wing 4.2 mm.

Rostrum dark gray; palpi black. Antennae black throughout, short; flagellar segments oval, the outer ones more elongate and slender; verticils relatively short. Head gray; anterior vertex broad.

Pronotum gray, the scutellum and pretergites testaceous yellow. Mesothorax almost uniformly dark gray, the praescutal interspaces a trifle more darkened; dorsopleural region obscure yellow; tuberculate pits small, widely separated, lying far before the level of the pseudosutural foveae. Halteres yellow. Legs with the coxae testaceous yellow; trochanters clearer yellow; remainder of legs broken. Wings with a very faint grayish tinge, the prearcular and costal fields more whitened; stigmal region scarcely differentiated; veins pale brown, more whitened in the paler fields. Veins beyond cord with conspicuous macrotrichia, with a further series on the distal third of vein 2*nd A*. Venation: Sc_1 ending about opposite the fork of *Rs*, Sc_2 far from its tip, about opposite one-third the length of *Rs; Rs* long and nearly straight, about twice R_3; R_2 about two-thirds to three-fourths R_{2+3+4}; vein R_3 and R_4 diverging at an acute angle (about 30°); cell 1*st* M_2 very small, about one-half as long as vein M_4; *m-cu* at midlength of cell 1*st* M_2.

Abdomen, including hypopygium, dark brown to brownish black. Male hypopygium in general structure much as in the subgenotype *knowltonia*, differing in the details, especially of the dististyles. Outer style stouter, including the head and neck portion. Intermediate style broader. Inner style more slender. Phallosomic cushion much the same in both species.

Habitat. California (San Bernardino County).

Holotype. ♂, East Barton Flats, San Bernardino Mts., altitude 6300 feet, at light, August 18, 1946 (J. L. Sperry).

I am very pleased to name this interesting cranefly for Mr. Noël Crickmer, of Borego, California, who has collaborated with the Sperrys in collecting numerous Tipulidae from California and elsewhere. The only species hitherto discovered is the subgenotype, *Erioptera* (*Gonomyodes*) *knowltonia* Alexander, of northen Utah. which differs conspicuously in the coloration, details of venation and structure of the male hypopygium. With this discovery of a second species, the subgeneric distinctions, particularly those shown in the male hypopygia, between *Gonomyodes* Alexander and *Gonempeda* Alexander become even more significant.

Cryptolabis (Cryptolabis) mixta n. sp.

Thorax dark brown, conspicuously patterned with yellowish white, the latter color including a broad dorsopleural line from the pronotum to the pleurotergite; scutellum yellow; a major yellow spot on the dorsal sternopleurite; male hypopygium with the dististyle relatively narrow, tapering gradually to the acute blackened tip, on outer margin at near two-thirds the length with a strong acute point; aedeagus relatively stout, straight, at apex abruptly narrowed and prolonged into a capillary tubule.

Male and Female. Length about 3.2-3.3 mm.; wing 3.8-4 mm.

Rostrum pale brown; palpi brownish black. Antennae dark brown; flagellar segments oval, the verticils exceeding the segments. Head with the front and orbits yellowish white, the center of vertex reddish brown.

Pronotum, pretergites and broad lateral mesonotal borders yellowish white, the color continued back over the wing root onto the dorsal postnotum; remainder of mesonotal praescutum and scutum dark brown; scutellum yellow; postnotum dark brown, variegated by yellowish white, as described. Pleura dark brown, with a major yellowish white area on the dorsal sternopleurite. Halteres pale. Legs with the fore coxae pale brownish testaceous; remaining coxae and all trochanters yellow; femora and tibiae obscure yellow, the tips narrowly darkened; tarsi brown. Wings subhyaline; veins brown. Numerous macrotrichia in cells beyond cord. Venation: *Rs* strongly sinuous, in alignment with the basal section of R_5; $R_2+_3+_4$ and R_2+_3 subequal; *m-cu* close to the fork of M_3+_4.

Abdomen dark brown. Male hypopygium with the dististyle relatively narrow, tapering gradually to the blackened acute spinous tip; on outer margin at near two-thirds the length with a strong acute point; outer face of style as far distad as this spine with strong scattered setae. Aedeagus relatively stout, straight, at apex abruptly narrowed and prolonged into a capillary tubule.

Habitat. California (Mariposa County).

Holotype. ♂, Bear Creek, Sierra National Forest, 10 miles west of Mariposa, July 25, 1946 (C. P. Alexander). *Paratopotypes.* 15 ♂ ♀.

The most similar described species is *Cryptolabis* (*Cryptolabis*) *sica* Alexander, of Arizona and southern Utah, which differs in the details of coloration and in the structure of the male hypopygium, including the broader dististyle and the differently formed aedeagus.

Cryptolabis (Cryptolabis) bidenticulata n. sp.

General coloration of thorax dark brown, variegated with light yellow, especially conspicuous as a stripe from the pronotum backward across the wing-root to the postnotum, with an additional area on the pleura; scutellum dark; femora obscure brownish yellow, the tips broadly blackened; wings weakly dusky, very restrictedly patterned with darker; $R_2 + _3 + _4$ long, equal to *r-m; m-cu* at midlength of $M_3 + _4$; male hypopygium with the dististyle conspicuously and evenly bidentate at apex; aedeagus relatively slender, the anterior end narrowed gradually into a long taillike extension.

Male. Length about 3.5 mm.; wing 4 mm.

Rostrum brown; palpi somewhat darker brown. Antennae brownish black throughout. Head dark brown, the front and orbits yellow.

Pronotum and pretergites light yellow, the color continued backward along the extreme dorsopleural region, around the wing root, onto the anterior postnotum, involving both the mediotergite and pleurotergites. Mesonotum uniformly dark brown excepting the very restricted obscure yellow humeral region of the praescutum, the more extensive outer posterior angles of the scutal lobes, and the postnotum, as described; scutellum dark. Pleura dark brown, patterned with light yellow, including the dorsal portion of the sternopleurite, the area continued cephalad onto the propleura which is almost uniformly pale. Halteres weakly infuscated. Legs with the coxae weakly darkened; trochanters obscure yellow; femora obscure brownish yellow, the tips broadly blackened; one detached leg, apparently a fore one, shows the femora almost entirely darkened; tibiae obscure brownish yellow, narrowly darkened at both base and apex; tarsi passing into black, the basitarsi chiefly pale. Wings with an exceedingly weak dusky tinge, the prearcular and costal fields somewhat more whitened; stigma, axilla and vague seams over the cord a trifle more darkened; veins dark brown, paler in the lighter portions. Macrotrichia of

wing cells relatively sparse, more or less restricted to the outer half or slightly more of the cells beyond cord, the bases of all these cells without trichia. Venation: *Rs* short and oblique, strongly sinuous; $R_2 + {}_3 + {}_4$ long, fully equal to *r-m* and about four times $R_2 + {}_3$, the latter shorter than R_2; *m-cu* at mid-length of $M_3 + {}_4$.

Abdomen dark brown, the hypopygium a trifle paler. Male hypopygium with the outer lobes large and conspicuous, with abundant long setae. Dististyle stout, conspicuously bidentate at apex, the two teeth subequal in size and shape. Aedeagus relatively slender, straight, the posterior end gradually narrowed into a long taillike extension.

Habitat. California (San Bernardino County).

Holotype. ♂, East Barton Flats, San Bernardino Mts., altitude 6300 feet, at light, July 20, 1946 (J. L. Sperry). *Paratopotypes.* ♂ ♀, July 14-16, 1946 (C. P. Alexander).

The most similar species include *Cryptolabis* (*Cryptolabis*) *sica* Alexander and *C.* (*C.*) *mixta* n. sp., both of which differ most evidently in the structure of the male hypopygium, particularly of the dististyle and aedeagus.

Ormosia (Ormosia) heptacantha n. sp.

General coloration of mesonotum reddish brown, the pleura and pleurotergite yellow; antennae (male) elongate, bead-like, the segments with exceedingly long outspreading verticils; wings pale brown, the stigma darker; cell M_2 open by the atrophy of basal section of M_3; Anal veins convergent; male hypopygium with the mesal face of basistyle with two strong blackened spines; phallosome with three further blackened spines, the lateral pair somewhat shorter.

Male. Length about 5 mm.; wing 5.5 mm.; antenna about 3.5 mm.

Female. Length about 5.5 mm.; wing 6 mm.

Rostrum brown; palpi black. Antennae (male) elongate; scape and pedicel brown, flagellum black; flagellar segments elongate, flask-shaped, the long apical necks subglabrous, the swollen bases with exceedingly long outspreading white verticils. Head light gray; anterior vertex relatively narrow.

Pronotum and pretergites yellow. Mesonotum pale reddish brown, the humeral region of praescutum yellow, the cephalic portion a trifle darker. Pleura and pleurotergite pale yellow. Halteres yellow. Legs with the coxae and trochanters yellow; remainder of legs broken. Wings broad, pale brown, the stigmal region darker; veins pale brown; macrotrichia still paler. Venation: Cell M_2 open by the atrophy of basal section of M_3; *m-cu* close to fork of *M;* Anal veins convergent, the distal half of *2nd A* sinuous.

Abdomen, including hypopygium, dark brown. Male hypopygium with the tergal lobe broad, its caudal margin with a broad V-shaped notch, at the base with pale membrane; lateral lobes at apex and on outer margin with strong fimbriations. Basistyle on mesal face with two strong blackened spines, the outer one larger. Outer dististyle scoop-shaped, darkened, the tip truncate; outer surface with microscopic appressed spinulae. Inner dististyle narrowed at apex into a dark colored cylindrical lobe. Phallosome comprised of three blackened spines that are more or less fused basally, the lateral spines or apophyses slightly shorter than the median one.

Habitat. California (Humboldt County).

Hollotype. ♂, Prairie Creek Camp, in Coastal Redwood forest. July 31,

1946 (C. P. Alexander). *Allotopotype*. ♀, pinned with type.

In the nature and arrangement of the spines on the mesal face of the basistyle, the hypopygium of the present fly is most like that of *Ormosia* (*Ormosia*) *pleuracantha* Alexander, of Oregon and northern California. In some details of the hypopygium a similarity likewise is shown to *O.* (*O.*) *furibunda* Alexander, of Oregon, but the relationship is not particularly close.

Ormosia (Ormosia) tricornis n. sp.

General coloration of thoracic notum dark brown; wings with a weak brown tinge, the stigma darker; male hypopygium with the tergite produced into a narrow spatula; outer dististyle complex, the outer lobe heavily blackened, produced into three strong spines; inner arm forking into two very long slender rods; inner dististyle a long narrow blade, before apex on outer margin with an erect black spine.

Male. Length about 3.8 mm.; wing 4.5 mm.

Rostrum and palpi black. Antennae black, of medium length, broken at midlength; basal flagellar segments subcylindrical, with one unusually long verticil on each segment, these unilaterally arranged, fully three times the segments. Head dark gray.

Pronotum dark brown; anterior pretergites light yellow. Mesonotum chiefly dark brown; lateral praescutal borders broadly more reddish brown; pleurotergite somewhat paler. Pleura testaceous brown. Halteres pale, especially the base of stem. Legs with the coxae brownish yellow; trochanters yellow; remainder of legs broken. Wings with a weak brownish tinge, the stigma darker; veins pale brown. Venation: Sc_1 ending nearly opposite R_2,Sc_2 opposite one-third the length of *Rs*; R_2 oblique, about twice as long as $R_2 + _3$; cell M_2 open by the atrophy of basal section of M_3; *m-cu* close to the fork of *M*; Anal veins generally divergent, vein *2nd A* weakly sinuous on distal third.

Abdomen dark brown, the hypopygium a trifle brighter. Male hypopygium with the appendage of the ninth tergite a triangular spatula, the base very narrow, thence expanded, the apex truncated with a median notch, the whole distal half with microscopic fimbriations to form a heart-shaped cushion; basal half with about a score of coarse setae. Outer dististyle complex, consisting of a compact blackened outer structure that terminates in three powerful spines; from the base of this mass arises a further strong arm that almost immediately forks into two long slender rods, each of which narrows at apex into a blackened spine, the two directed toward one another, forceps-like. Inner dististyle subapical in origin, appearing as a long narrow blade, some distance before apex on outer margin with an erect black spine. Each gonapophysis appearing as a slender blackened spine, with a smaller blackened spike at base. Aedeagus small and simple, straight, the apex obtuse, the total length subequal to the longest spine of the apophysis.

Habitat. California (Humboldt County).

Holotype. ♂, Prairie Creek Camp, in Coastal Redwood forest, July 31, 1946 (C. P. Alexander).

The peculiar male hypopygium, especially the inner dististyle and gonapophyses, is much as in *Ormosia* (*Ormosia*) *unicornis* Alexander, of Oregon (Cascade Mountain foothills) but the structure of the outer dististyle is entirely different.

Ormosia (Ormosia) legata n. sp.

Allied to *cornuta;* size relatively large (wing, male, 5.5 mm.); general coloration light brownish gray; flagellar segments of male antennae long-cylindrical, with long outspreading verticils; wings with a brownish tinge; cell M_2 open by atrophy of basal section of M_3; Anal veins convergent; male hypopygium with the outer dististyle a compact blackened mass that bears four spinous points; two sets of apophyses, the outer pair appearing as twisted yellow blades that gradually narrow into a slender spine; inner apophysis smaller, blackened, terminating abruptly in a strong straight spine.

Male. Length about 4.6 mm.; wing 5.5 mm.

Female. Length about 5.8-6 mm.; wing 6.2-6.5 mm.

Rostum and palpi dark brown. Antennae brown, the basal segments somewhat paler; antennae of male broken near base, the proximal flagellar segments long-cylindrical, indicating a relatively long organ; flagellar segments with very long and conspicuous white verticils. Head gray.

Thoracic dorsum light brownish gray, the pronotal scutellum and pretergites yellow; praescutum with a delicate brown median vitta that is slightly expanded in front; posterior sclerites of notum light brown, the scutellum testaceous; vestiture of notum yellow, long and conspicuous. Pleura and pleurotergite infuscated. Halteres yellow. Legs with coxae and trochanters yellow; remainder of legs brown, the color produced in part by dark vestiture. Wings with a brownish tinge, the stigma darker brown; vague more whitish areas in the vicinity of cord; veins brown. Venation: *Rs* long, straight; $R_2 + {}_3 + {}_4$ from one-fourth to one-half longer than the basal section of R_5; $R_2 + {}_3$ and R_2 subequal; cell M_2 open by the atrophy of basal section of M_3; *m-cu* at or close to the fork of *M;* Anal veins convergent, *2nd A* sinuous on its outer half.

Abdomen dark brown; genital segment of female more testaceous yellow Male hypopygium with the tergal lobes produced into long yellow fimbriations. Outer dististyle a compact blackened structure that terminates in spinous points, there being a more flattened scabrous outer projection and two acute slender spines on the inner apical portion; besides these, at base of inner face, with a further strong curved spine. Inner dististyle pale, dilated on more than the basal half, the apex suddenly narrowed. Two sets of apophyses, the outer pair appearing as long yellow blades that are twisted or bent at near midlength, the outer portion gradually narrowed into a long slender apical spine; inner apophysis smaller, blackened, terminating in a strong straight spine. Aedeagus small and simple.

Habitat. California (Kings Canyon National Park).

Holotype. ♂, near the General Grant Tree; swept from dense thickets of *Azalea occidentalis* along a small clear stream, July 19, 1946 (C. P. Alexander). *Allotopotype.* ♀. *Paratopotypes.* ♀♀.

Ormosia (Ormosia) legata is readily distinguished from *O.* (*O.*) *cornuta* (Doane), *O.* (*O.*) *subcornuta* Alexander, and other allied species by the very distinct male hypopygium, particularly the outer dististyle and the gonapophyses.

TWO NEW SATYRIDS FROM NORTH AMERICA

BY RALPH L. CHERMOCK,
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Minois meadi mexicana, new subspecies.

Male Length of primaries (measured from the base of the wing to the apex) 25-26 mm. Genitalia identical with those of *Minois meadi meadi*. Upper surface: the primaries as in typical *meadi*, with two small dark ocelli ringed with light reddish-yellow; the pupils reduced in the anterior ocelli and lacking in the posterior; the area between the occelli may be suffused with reddish-yellow. Secondaries as in typical *meadi*, with a well developed submarginal ocellus between veins Cu_1 and Cu_2, which may or may not be pupilled with white. Lower surface: primaries similar to *M. m. meadi*. Secondaries with a well developed submarginal ocellus between Cu_1 and Cu_2; additional ocelli may also be present between M_1 and M_2, and Cu_1 and 2A. The ground color is homogeneous dull brown, with darker striae which are more sparsely distributed than in typical *meadi*, and tend to disappear in the limbal area. The dark transverse bands of *meadi* have almost completely disappeared.

Female. Length of primaries 31 mm. Upper surface as in typical *meadi*, however an additional submarginal ocellus may be present between veins M_3 and Cu_1 of the secondaries. The lower surface of the primaries are as in *M. m. meadi* The secondaries are more homogeneous in color, and the discal bands tend to disappear. Small submarginal ocelli are present between the following veins: Rs and M_1; M_1 and M_2; M_3 and Cu_1; Cu_1 and Cu_2; Cu_2 and 2A.

Holotype male, Chihuahua, Mexico, August 30 (Townsend). *Allotype*: female, same data. *Paratypes* 2 males and 1 female, same data. All specimens are in the collection of the Carnegie Museum, Pittsurgh, Pa.

This new subspecies differs from typical *meadi* in its larger size, the homogeneous color of the lower surface of the secondaries, the loss of the transverse discal bands, and the presence of additional submarginal ocelli.

Typical*minois meadi meadi* (Edwards) comes from near Denver, Colorado. Wind (1946) has recently described a new subspecies from Marfa Alpine, Texas, which he named *melania*. Topotypical specimens of *melania* were compared with the types of *M. meadi* (Edwards) in the Carnegie Museum, and were found to be identical except for the presence of apical ocelli on the lower surface of the secondaries. However, numerous Colorado specimens of both sexes possess these apical celli, and it seems to be the normal trait of the females. Edwards' type male is extremely dark, with no red suffusion on the upper surface of the primaries other than the light ring around the ocelli. This character is supposedly diagnostic of *melania*. Because no characters can be attributed to *melania* which would separate it from Colorado *meadi*, I feel that it should be placed in synonymy.

Wind (1946) has described a new subspecies of *Euptychia rubricata* which he named *smithorum*. The type series came from Marfa Alpine, Texas, and the Chisos Mountains, Texas. He contrasted the new subspecies with Arizona specimens which he considered to be typical. However, Edwards (1872) described *Euptychia rubricata* from specimens collected at Waco, Texas. Topotypical specimens of *smithorum* were compared with the types of *Euptychia rubricata in* the Carnegie Museum collection, and were found to be identical. Consequently, *smithorum* becomes a synonym of *rubricata*. The distinct Arizona subspecies is described as follows.

Euptychia rubricata cheneyorum, new subspecies.

Male. Upper surface: the brick-red patch of the primaries is usually limited to the interspaces between veins M_3 and Cu_1, and Cu_1 and Cu_2. Occasion-

ally, it may extend above or below these veins, or partially invade the apex of the cell. In *E. r. rubricata*. the red patch always includes the distal half of the cell, extends well below Cu_2, and above M_1 to M_2, and sometimes even beyond the latter vein. On the secondaries, the red patch is large, extending from the submarginal band to the cell, completely filling the interspaces between M_3 and Cu_1, and Cu_1 and Cu_2 and usually extending well beyond veins M_3 and Cu_2; frequently filling the interspaces between M_2 and M_3, and Cu_1 and 2A. In typical *rubricata*, this red patch does not reach the submarginal band, and fills only the interspace between M_3 and Cu_1, extending slightly into the adjacent interspaces.

On the lower surface of the secondaries, the wing is homogeneously dusted with whitish-gray scales; the transverse dark bands on either side of the discal area are thin and dark brown in color. The rudimentary submarginal ocelli between M_2 and M_3, and M_3 and Cu_1 are reduced to a plain silver spot, or completely lacking. In *E. r. rubricata*, the ground color is tan, with the limbal area often paler and contrasting with the discal area. The transverse bands are broader, inwardly margined with reddish-brown. The ocelli between M_2 and M_3, and M_3 and Cu_1 are large, and ringed with bright tan and brown.

The male genitalia are identical to those of the typical suspecies.

Female. Exhibits the same diagnostic characters of the male, although the red patch of the upper surface of the secondaries is slightly reduced. In *E. r. rubricata*, however, this patch is usually very reduced, frequently disappearing completely.

Length of the primaries (measured from the base of the wing to the apex) in the male is 17-20 mm., average 18 mm.; in the female 20-22 mm., average 21.5 mm.

Holotype: male, Madera Canyon, Santa Rita Mts., Pima Co., Arizona, elevation 5800 feet, June 16, 1947 (C. D. Cheney and O. D. Chermock). *Allotype*: female, same locality and collectors, June 22, 1946. *Paratypes*: R. L. Chermock collection: 23 males and 1 female, Carr Canyon, Huachuca Mts., Cochise Co., Arizona, elevation 5200 feet, June 12, 1947 (C. D. Cheney and O. D. Chermock): 5 males and 3 females, Mount Lemmon Prison Road, Santa Catalina Mts., Pima Co., Arizona, June 9, 1947, June 18, 1946 (C. D. Cheney and O. D. Chermock); 5 males, Pinery Canyon, Chiricahua Mts., Cochise Co., Arizona, elevation 6200 feet, June 20, 1947 (C. D. Cheney and O. D. Chermock); 3 males, same locality, June 17, 1932 (Duncan); 15 males and 6 females, Madera Canyon, Santa Rita Mts., Pima Co., Arizona, Elevation 5800 feet, June 22, 1946, June 26, 1946, June 28, 1946, June 16, 1947, June23, 1947, July 10, 1947, (C. D. Cheney and O. D. Chermock); 1 male, same locality, June 22, 1932 (Duncan); 7 males, Ruby, Arizona, elevation 4200 feet, June 2, 1947 (C. D. Cheney and O. D. Chermock); 1 male and 1 female, Palmerlee, Arizona. Cornell University collection: 1 male, Huachuca Mts. Cochise Co., Arizona, May 26, 1910 (V. L. Clemence); 2 females, Arizona (Morrison); 1 female, Post Creek, Fort Grant, Pinaleno Mts., Arizona, July 18, 1917. Stallings and Turner collection: 1 male, Cochise Co., Arizona, June 8, 1940. F. H. Chermock collection: 18 males and 3 females, Pinery Canyon, Chiricahua Mts., Arizona, June 17, 1932 (Duncan); 7 males, Huachuca Mts., Arizona, May 30-31, 1935.

This new subspecies is named in honor of Mr. and Mrs. C. D. Cheney of Tucson, Arizona, to whom I am indebted for the large number of specimens in the type series, along with numerous other butterflies from southern Arizona..

I wish to express my thanks to Dr. Walter Sweadner of the Carnegie Museum for the loan of the series of *Minois meadi mexicana*, and his permission to study Edwards types along with other material in their collection. I also wish to thank Mr. & Mrs. C. D. Cheney and my wife for collecting the large series of *Euptychia rubricata cheneyorum* for study. I am indebted to Dr. W. T. M. Forbes of Cornell University for his many helpful suggestions.

AN OUTBREAK OF *AEROPEDELLUS CLAVATUS* (THOMAS) (ORTHOPTERA, ACRIDIDAE)[1]

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In west-central Saskatchewan at a single location 18 miles southwest of Laporte, *Aeropedellus clavatus* (Thomas) appeared in outbreak numbers and destroyed 300 acres of crop in 1936.

The outbreak was resricted to two adjoining fields each of 300 acres, but the two differed widely in the amount of damage. These fields were adjacent to the South Saskatchewan River, with a mile of prairie extending down to the river on one side and two section of native prairie on the other. The soil at this location is heavy clay, which is typical of the district.

From the lack of early observations it was not possible to state definitely whether the nymphs of *A. clavatus* hatched within these fields or invaded them. However, the general early distribution suggests hatching in the fields. Each field had been in wheat in 1933 and both were disked in the spring of 1936 before again being sown to wheat. The main difference between the fields, seemed to be the date of seeding and a timely rain after the first field was sown. The most severe damage occurred to the later sown crop. This appears to be an unique record of this species causing such severe crop damage.

The only Alberta record of *A. clavatus* occurring in such numbers as to be of possible economic importance was at one locality in east-central Alberta in June, 1933 (White '43), while in south-western Manitoba there is a similar record for June, 1934 (Handford '34). The species has not been included among the forty most important species of grasshoppers responsible for outbreaks throughout the United States from 1934 to 1936 inclusive, nor has it been mentioned in any publications on reports as being of economic importance. Uvarov ('28) in his appraisal of the locust and grasshopper outbreaks of the world makes no mention of this species.

A. clavatus is widely distributed throughout the North American Plains area. It occurs from Arizona north to Alaska. In Alberta, White ('42) reports that *A. clavatus* has been observed from the United States border northward to the Peace River district and Lake Athabaska, occurring in the mountains, the wooded areas and open prairies. He makes the interesting comment that ecologically it is the most widely distributed grasshopper in that province. Hebard ('32) reports the eastern limits of the species as including approximately the southwestern half of Minnesota. It is evident that this species is quite cosmopolitan in its habitats and this has been observed in Saskatchewan. However, the outbreak developed in one of the driest open prairie areas of this province.

In the northern Great Plains, which includes the prairie regions of Saskatchewan, Alberta and Manitoba, *Melanoplus mexicanus mexicanus* (Sauss.) and to a lesser degree *Camnula pellucida* (Scud.), *M. bivittatus* (Say) and *M. packardii* Scud. have been responsible for continuous outbreaks of varying intensity from 1931 to 1944 inclusive. The most severe outbreak was in 1934. The following year, 1935, was unusually wet and resulted in a marked

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reduction in the number of these species in Saskatchewan during 1936. *A. clavatus*, however, appeared in unprecedented numbers in the very restricted locality at Laporte, Saskatchewan in 1936, and yet elsewhere throughout the northern prairie area and adjacent parklands where this species has been collected, no conspicuous increase in infestation was evident. The severe outbreak at Laporte was of particular interest since it was a reverse trend from that of the major economic species in this same area. The species was not present in outbreak numbers prior to 1936 and since then has disappeared entirely as a pest.

REFERENCES

Handford, R. H., 1934. Unpublished report. Dom. Ent. Lab., Brandon, Man.
Hebard, Morgan, 1932. The Orthoptera of Minnesota: University of Minn. Agric. Exp. Sta. Tech. Bull. 85.
Uvarov, B. P., 1928. Locusts and grasshoppers, a hand book to their study and control: Imperial Bur. of Ent. London.
White, R. M., 1942, 1943. Personal correspondence. Dom. Ent. Lab., Lethbridge, Alberta.

BOOK NOTICE

"Chemistry and Uses of Insecticides" by E. R. De Ong. 345 pages, 18 illustrations. Reinhold Publishing Company, New York. 1948. $6.00.

The author of this book has had long and extensive experience in the field of entomology. At one time in charge of entomology at the University Farm, Davis, Cal., he was later director of the insecticide laboratory of the University of California at Berkeley. For twenty years, during ten of which he was Secretary-Treasurer of the Pacific Insecticide Institute, he has acted as a consultant entomologist and agricultural technologist, and as such has been well known and respected in the western states.

This book was designed to meet the growing need of a somewhat general but comprehensive reference to the established as well as to some of the promising, more recently introduced, insecticides. Chapters are devoted to arsenicals, coppers, sulphurs, miscellaneous inorganic compounds, oils, fumigants, plant derivatives, synthetic organic compounds, and heat, cold and radiation as insecticides. The text material is well arranged, usually including under the various products the chemical nature, its effectiveness on various type of insects, cautions in its use, methods of application, and other data. The author disclaims responsibility for the correctness of dosages and use of materials for any specific occasion on the grounds that as insecticidal dosage and time of application are very variable, local agricultural officials and experienced operators should be consulted.

This book includes a number of useful appendixes such as,— Dictionary of Insecticides, Glossary, Legal Regulations (U.S.) Covering the Manufacture and Sale of Insecticides, Official Antidotes, ASTM Standards, Conversion Tables and Equivalents, Miscellaneous Data, and List of United States Patents. Of the appendixes, the glossary is of least value, only twenty terms being defined and the definitions not always adequate, — as "Fugicide — lethal in action". The appendix headed "Miscellaneous Data" (in reality commencing on page 312, not on page 314 as in "Contents") is made up of useful data on Dusts and Soil Insecticides, Range of Chemical and Physical Characteristics of the Common Non-metallic Mineral Insecticide Diluents — Clays, Talcs, Silicas, and Humidity Regulations.

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